THE APPLICABILITY OF THE ARMY PHYSICAL FITNESS TEST IN THE CONTEMPORARY OPERATING ENVIRONMENT

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE APPLICABILITY OF THE ARMY PHYSICAL FITNESS TEST IN THE CONTEMPORARY OPERATING ENVIRONMENT, by James. E. Batchelor, 119 pages.

The purpose of this study was to determine if there is any validity to using the current Army Physical Fitness Test (APFT) to gauge Soldier readiness for combat. The study was conducted in four stages. The APFT tasks; pushup, sit-up, and run were analyzed to determine what body actions and associated muscles were used to conduct them and in what manner. In the second stage, a set of combat oriented tasks from the Training and Doctrine Command (TRADOC) physical training guide was analyzed on the same basis as the APFT tasks. In the third stage, the top six tasks from a survey of Intermediate Level Education (ILE) majors were then analyzed on the same basis as the APFT tasks and the TRADOC tasks. Finally, these three sets of tasks were compared based on body actions and their associated muscles and whether they were used to perform isometric, concentric, or eccentric contractions as an element of endurance or strength. The results showed that the APFT has major shortfalls in testing elements of both the TRADOC tasks and the "combat tasks" from the survey. Most notably, the APFT tests endurance almost exclusively, while the TRADOC tasks and the "combat tasks" require strength.

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ACRONYMS

APFRI	Army Physical Readiness Institute
APFT	Army Physical Fitness Test
BFPT	Battle Focused Physical Training
BFT	Battle Focused Training
CALL	Center for Army Lessons Learned
CASEVAC	Casualty Evacuation
CFT	Combat Fitness test
CGSC	Command and General Staff College
COE	Contemporary Operating Environment
DoD	Department of Defense
FM	Field Manual
FOB	Forward Operating Base
GWOT	Global War on Terror
HMMWV	High Mobility Multi Wheeled Vehicle
IED	Improvised Explosive Device
ILE	Intermediate Level Education
IMT	Individual Movement Technique
LTC	Lieutenant Colonel
LTG	Lieutenant General
MMAS	Master of Military Art and Science
MOS	Military Occupational Specialty
NCO	Non-Commissioned Officer
NCOER	Non-Commissioned Officer Evaluation Report

OEF	Operation Enduring Freedom
OER	Officer Evaluation Report
OIF	Operation Iraqi Freedom
PRT	Physical Readiness Training
PT	Physical Training
RAW	Ranger Athlete Warrrior
RPG	Rocket Propelled Grenade
SAF	Small Arms Fire
SAW	Squad Automatic Weapon
SBCT	Stryker Brigade Combat Team
SOP	Standard Operating Procedure
TRADOC	Training and Doctrine Command
USAPFS	United States Army Physical Fitness School

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CHAPTER 1

INTRODUCTION

In 2004, the commander of a Brigade Headquarters and Headquarters Company (HHC) operating in northern Iraq maintained the responsibility, with the help of a dedicated group of Non-Commisioned Officers and Soldiers, to conduct casualty evacuation (CASEVAC) operations on the Forward Operating Base (FOB). One afternoon in late May, the FOB received seven or eight rounds of incoming 60mm and 82mm mortar fire which impacted on one of the largest blocks of living containers. As per the Standing Operating Procedure (SOP), once the incoming rounds ceased, the CASEVAC element fanned out to find the point of impact. The company commander was the first individual from this element to locate the impacts. Arriving on the scene, he found one of his Soldiers, bleeding and unresponsive, lying just outside the door of his container which had suffered a direct hit from one of the rounds. The container was engulfed in flames and the Soldier's ammunition had begun to "cook off" in the heat. Another Soldier, not part of the actual CASEVAC element, had attempted to move the casualty out of danger but lacked the strength, and was forced to wait until someone else arrived. This Soldier had regularly, in accordance with Army regulations, passed the Army Physical Fitness Test (APFT) in the past.

In February of the same year, a female Soldier from the same unit was on a convoy in the same area of operations. The convoy came under a combined arms insurgent attack consisting of an improvised explosive device (IED), rocket propelled grenades (RPGs), and small arms fire (SAF). This female Soldier was gunner for the M-

249 Squad Automatic Weapon (SAW) in the cupola of the High Mobility Multi-Wheeled Vehicle (HMMWV) she was riding in. Upon first contact, a soldier in the back of the vehicle was hit with a RPG, and the female gunner was hit in the body armor with an AK-74 round. She dropped down into the vehicle and administered first aid to the wounded passenger, applying a tourniquet, and then stood back up in the cupola to engage the enemy with her machine gun. She succeeded in killing several insurgents before the convoy was able to move out of the kill zone. She received the Bronze Star for valor for her actions that day. She was a military intelligence analyst, not an infantryman.

In July 1950, Task Force Smith, a poorly prepared American force went to fight on the Korean peninsula. This first American unit to engage North Korean forces was charged with defending the road between Suwon and Osan. They were physically and materially unprepared for the demands of combat and were routed by a better prepared North Korean Army. At the conclusion of the battle, the unit had managed to slow the North Korean advance by half a day, after suffering 150 dead, wounded, and missing and inflicting approximately 130 casualties on the North Koreans (Tucker, n.d.) The lessons learned from this task force were that U.S. Soldiers had to be prepared for the physical demands of combat. The Army could not concentrate its physical training programs solely on the APFT. (U.S. Department of the Army, 1998, iii.)

In the current war in Iraq and Afghanistan, there are no “front lines.” Every Soldier, no matter what his or her job, has the potential to be in a position from which he or she may be required to shoot, move, and communicate. In order to effectively conduct these activities, all Soldiers must be capable of conducting some base level of strenuous

physical activity. It is the intent of this thesis to identify these base level physical capabilities and conduct a cross-walk between them and the current APFT to ascertain whether or not this test is a valid measure. If it is not a valid measure, its shortfalls will be identified and a proposed course of action to make up these shortfalls will be identified.

The Department of Defense (DoD) considers fitness tests a reflection of the general health and well-being of a service member, but acknowledges that a higher level of fitness is required to perform job-related activities (U.S. General Accounting office,1998, 3.) Currently the Army only has one standardized measure of fitness for Soldiers across the service (U.S. Department of the Army, 1998,14-1): the APFT, which according to the previously mentioned commission is not meant to be a measure of combat fitness. Individual units have compensated for this shortcoming by developing their own programs, one example being the Ranger Athlete Warrior (RAW) program developed by the 75th Ranger Regiment (McMillan, 2007 ,5-8.) Another example at the conventional level is the 5th Battalion 20th Infantry Regiment and their battalion physical fitness program which is based on a unit physical fitness Standard Operating Procedure (SOP) (U.S. Department of the Army, n.d.) The APFT is a numerical measure of physical fitness based on a Soldier's ability to perform pushups, sit-ups, and a two mile run (U.S. Department of the Army, 1998, 14-1-14-26.) According to several sources on the Company Command web site, several Master's of Military Art and Science (MMAS) theses, and multiple opinion and journal articles which will be reviewed in chapter two, within the Army there are those who do not believe that training for the APFT measure soldier readiness for the rigors of combat. In a January 2006 survey of Army company

commanders on their attitudes about physical training, 64% of respondents believed that "Warfighter PT," (a training method based on conditioning for specific combat skills) had the most impact on their Soldiers in combat. Only 16% said that APFT and FM 21-20 style standard PT had the most impact on their Soldiers (Company Command, 2006.) This leads to the hypothesis that the current APFT is not a valid measure of fitness required to conduct operations in the Contemporary Operating Environment (COE.) The main questions that this thesis will attempt to answer are:

1. What muscles does the APFT test and how?

2. Given that the APFT by its own definitions is not meant to test for combat readiness, does it in any way measure the muscles or body actions required to meet the physical demands of combat that the Army identifies?

3. What is a valid set of "combat tasks" that a soldier should be capable of conducting, as dictated by U.S. Army majors in Intermediate Level Education (ILE) class 08-01?

4. Does the APFT in any way measure the muscles or body actions required to meet the "combat tasks" identified by these majors?

5. If it does not, how could this information be used to develop a new or extended physical fitness test which may more readily measure these combat tasks?

According to the printed standards in the Army Physical Fitness Manual, while conducting the APFT, a soldier executes as many pushups as possible in two minutes, as many sit-ups as possible in two minutes, and a two-mile run as fast as possible. Points from zero to one hundred are awarded in each event based on the number of repetitions (for pushups and sit ups) or speed (for the run), age, and sex. For example, a male

between the ages of seventeen and twenty-one earns sixty points for doing forty-two correct pushups, while a female of the same age earns one hundred points for the same number. The points earned in each event are added together for a total score out of a maximum of three hundred. The Army standard for passing the test is one hundred and eighty points with a minimum of sixty points in each event (U.S. Department of the Army, 1998, 14-1-14-26.)

The availability of a numeric score provides commanders an objective measure of unit physical readiness as evidenced by post-wide award incentives such as the Silver Streamer award available at Schofield Barracks, Hawaii, which is awarded to a company with an average APFT score of 270 or greater. It has become generally accepted to use these scores and awards as a measure of success in Officer Evaluation Reports (OERs) and Non-Commissioned Officer Evaluation Reports (NCOERs) (Preston, 2004.) However, some commanders have begun to realize that these APFT scores are not the true measure of unit physical readiness that they previously sought and have thus reduced the emphasis on them and began to develop unit programs as discussed earlier. The Army Physical Fitness Manual actually suggests that unit commanders should develop these programs and standards based on their unit's mission (U.S. Department of the Army, 1998, 14-2.) Consequently commanders have begun to look to Battle Focused Physical Training (BFPT) programs, such as obstacle courses (U.S. Department of the Army, 2003, 91-109,) to prepare soldiers for combat, but currently there is no standard measure of success across the service. This BFPT is generally defined as that which requires soldiers to emulate tasks that they would be expected to accomplish in combat, usually with some of the same equipment, such as a helmet and body armor (Honore and

Cerjan, 2002.) One example of this BFPT would be a buddy carry to simulate CASEVAC operations in a combat environment.

Some Army leaders have taken some steps to change the way that units, lower level leaders and Soldiers look at physical training (Company Command, 2006), but there has been no real progress in creating an Army-wide measure of Soldier readiness for the rigors of combat In 2000, the U.S. Army Physical Fitness School (USAPFS) developed the Army Physical Readiness Training (PRT) concept. This concept focused on a shift from training for the APFT to training for combat tasks. However in 2002, the Army drifted away from the draft program with the intent that it be re-visited at some future point (U.S. Department of the Army, "History of the U.S. Army Physical Fitness School.") A slightly more successful attempt was the publication of the TRADOC (Training and Doctrine Command) Physical Training Guide. This publication identifies battle focused physical tasks soldiers should be trained on in basic training, but still does not offer a testing method. The fact that these tasks are stressed in the environment that serves as the starting point for all enlisted personnel, may mean that these skills are deemed important enough for a Soldier to carry throughout his or her career..

There are several assumptions to take into account for this thesis. The primary assumption is that the current APFT is not a valid measure of fitness for the COE. If this assumption is correct, then it leads to some secondary assumptions. The first is that there is a set of combat tasks which may apply to all Soldiers in combat. The next is that these tasks can be broken down into body actions and muscles used. A third assumption is that there are exercises that measure these components. Further, this thesis assumes fitness information found within military manuals, professional works, and papers is factually

correct. A final critical assumption is that feedback from Soldiers with operational experience during identification of the combat tasks to be tested is candid.

The significance of this study is twofold. The first objective is to educate the military on the state of the current APFT. It is necessary that the Army understand that the APFT can not be counted on to provide an accurate measure of the fitness required of Soldiers in combat. The thesis will identify physical attributes or skills necessary for all Soldiers to be physically capable of conducting during operations in the current environment. The preferred endstate would be to attract General Officer level attention to this study and the initial findings and information would be utilized by the Army Physical Readiness Institute (APFRI,) to develop a new or additional physical fitness test. This test would be used across the Army to more accurately assess physical readiness across all branches, Military Occupational Specialties (MOSs), and genders. As Army units train for this test, they will be training their Soldiers to meet the physical demands of combat.

This chapter has discussed the background of the APFT and how it seems to be generally used across the Army. It has touched on some prevailing attitudes about the test and its validity and whether or not the Army is conducting combat focused training. The next chapter will explore some of the current literature on training in general and physical training in particular within the Army. This will be accomplished by reviewing the current attitudes expressed in professional forums and current publications followed by examination of Army documents and training manuals. The chapter will also explore some of what the Marine Corps is thinking about this same issue.

CHAPTER 2

LITERATURE REVIEW

There has been a vocal portion of the Army's population who do not believe that the current Army Physical Fitness Test (APFT) is an adequate measure of combat fitness (Company Command, 2006.) Chapter one makes the initial argument for conducting combat focused physical training and testing which is more valid for the Contemporary Operating Environment (COE.) This chapter in turn will attempt to explore the current literature on the subject. There are volumes of information available concerning physical fitness and its role in the Army. The primary sources are journal articles, military manuals, military websites, and books. The applicable sources for this particular thesis fall into four categories: background information, training attitudes in general, physical training attitudes specifically, and fitness basics.

The background information for this thesis consists of Army field manuals (FMs), Congressional reports, and historical references. This background information attempts to answer the questions of how the current APFT came about and what it was specifically intended to measure. It is also meant to illustrate the historical importance of physical fitness and readiness on the battlefield by specifying two different actions from recent and not-so-recent events. The Army FM 21-20, is the base document which guides physical fitness programs throughout the Army. It states specifically that the APFT is a measure of general health and wellness. The TRADOC fitness guide echoes this sentiment that the APFT is meant to be a measure of Soldier wellness. Several reports to Congress also reflect this view, not only for the Army, but across the services. According

to these sources then, the APFT is not meant to provide any type of measure for combat specific tasks.

There are numerous anecdotal examples from across the body of non-fiction war literature of the physical requirements of combat. Hampton Sides, the author of *Ghost Soldiers*, provides a historical look at the physical demands of a group of Rangers who needed to move approximately 30 miles in just a couple of days in order to conduct a combat operation and then back over the same distance. Another example is journalist and author, Mark Bowden's depiction of another group of Rangers' foot movement out of enemy held territory, while under fire, after approximately 14 hours of continuous combat operations in Somalia (Bowden, 1999, 286-289.) These two examples, among many, illustrate an easily recognizable physical task, in this case moving under a load, in conjunction with a combat operation.

These aforementioned sources help to explain the purpose of the APFT and the importance of physical fitness in combat. There is limited information on the specific history of how the Army developed the current PT test. The best information available is located on the US Army Physical Fitness School (USAPFS) web site, which states that the Army instituted the most recent version of the APFT standards in 1995. It is general, albeit unsubstantiated, military knowledge that one reason the Army conducts its current APFT is that it does not require special equipment and can be given anywhere. Another shortfall of the available literature is a lack of official guidance identifying what a Soldier must be able to physically accomplish in combat.

The next grouping of the available literature is general Army training attitudes and beliefs. The current Army culture centers on combat, whereas before September 11,

2001, it was centered on training. Units stayed in a constant cycle of training that revolved around a rotation at one of the maneuver training centers. A commonly heard platitude of this training Army was "train as you fight," which loosely meant that commanders and leaders expected to replicate combat conditions as closely as possible during all training opportunities. Within the group of literature focused on training attitudes, there are professional readings and articles from leaders in the Contemporary Operating Environment (COE), which support this "train as you fight" mentality.

There are several professional books that devote themselves to the "train as you fight" mentality. The most notable ones that will be cited in this work are LTG Arthur S. Collins' (retired) *Common Sense Training* and LTC Dave Grossman's (retired) *On Killing* and *On Combat*. LTG Collins' book favors a full spectrum approach to training from staff operations, to field training, to combat focused physical training (which will be discussed again.) He believed that all daily business, such as staff work, running ranges, and conducting maintenance, must be approached from a combat focused point of view. Grossman drives home his points on training for combat when he specifically discusses killing in *On Killing*. He expresses the need to de-sensitize soldiers by presenting realistic targetry in training, among other techniques. In *On Combat*, he takes it a step further by asserting the need to train soldiers in the most stressful, painful, realistic environment possible in order to prepare them for combat. Both of these authors offer straight forward explanations for the need to train for combat and not simply for the sake of training. By doing so, the military is preparing Soldiers to replicate tasks in combat that they have already replicated numerous times in training.

Current commanders and Non-commissioned officers (NCOs) in the field support Collins's and Grossman's views. The website companycommand.army.mil and the Center for Army Lessons Learned (CALL) contain multiple articles from Soldiers currently involved in the fight. These Soldiers provide multiple thoughts and examples, if not always in the most polished and professional formats, of the training necessary to fight and survive on the battlefield. The vast majority highly encourage battle focused training. In general the Army does appear to be moving toward a highly battle focused training methodology. Current leaders at the highest levels espouse the importance and utility of battle focused training (Honore and Cerjan, 2002.) This idea is nothing new, as evidenced by Collins' 1978 original publication date. However, the current threat of real combat has probably caused Soldiers and leaders to take the term "battle focused training" to heart. In these professional forums, there seems to be a minority who felt like they had more important tasks than physical readiness to perform in preparation for deployment, but they are in the minority.

The third category of the reviewed literature focuses on the current physical training attitudes within the military. This specific category is not to be confused with the previous category of general training attitudes. Although the reader will find that the two are extremely similar, the "physical fitness" portion is the difference. With a few exceptions, this literature consists almost solely of articles and observations from the CALL and company command websites. The generally shared characteristics though are the expressions of the need to conduct BFPT.

In *Common Sense Training*, Collins not only understands the importance of battle focused training in general, but he shows an understanding of the need to conduct combat

focused physical training (PT) as well (Collins, 1998, 174-176.) The most recent version of FM 21-20 also expresses the need for combat focused PT. It specifically calls on leaders to ensure that their units train for combat, not the APFT (U.S. Department of the Army, 1998, 14-1.) The TRADOC fitness manual expresses the same concern that leaders train their units for combat. It also implies a set of physical battle tasks, alluded to earlier, that Soldiers need to be trained on (U.S. Department of the Army, 2003, 160-166.) These examples show that the Army has moved, although in fits and starts, and continues to move, toward a more combat focused program.

Commanders on the battlefield realize the importance of combat focused PT. From numerous CALL articles and pieces on the Company Command website, NCOs, officers, and commanders are instituting combat focused PT programs at home station and in theater. The vast majority express a belief in this approach to combat focused PT over an APFT based approach. Even Cadets at the United States Military Academy are faced with an obstacle course type physical fitness test, which is specifically meant to test combat fitness (Bartelt, 2008.) One issue for younger leaders appears to be a disconnect between the identification of the need and the practical institution of a combat focused program. The Army as a whole, especially down at the operator level, seems to agree that physical training should be based on the physical requirements of combat and not on successful completion of the APFT. This consensus is a generalization based on leaders who felt the need to express their opinions in the web forums already mentioned. As with all generalizations, there are some dissenters who appear to be happy with the APFT-focused PT programs at their unit level.

The Marine Corps is also currently wrestling with the issue of combat focused physical training and testing. There are opinion pieces in their professional forums expressing dissatisfaction with the Physical Fitness Test (Molofsky,1997.) One individual, not only expressed dissatisfaction, but made a rather in-depth proposal consisting of an obstacle course based test with which to test combat fitness (Harvey, 1998.) The Marine Corps has heard the cry and developed a supplemental Combat Fitness Test, which will be instituted in Fiscal Year (FY) 09. It consists of approximately 800 yards of Individual Movement Technique (IMT), fireman's carry, casualty drag, grenade throw, and ammunition re-supply (Tilghman, 2008.) This test will supposedly fill the void between testing general fitness and combat fitness.

The last category of literature is the technical background. This body of knowledge consists of works that deal with basic fitness, anatomy, kinesiology, and biomechanics found in the Army manuals, commercial fitness programs, and professional journals. The current FM 21-20 is an excellent general fitness resource. It covers all aspects of fitness with specific training programs and systems. It will constitute one of the base documents used in the analysis of the current APFT and a set of identifiable combat physical tasks. The TRADOC fitness manual is a secondary source of this same information. This manual does however identify combat tasks which will be used later in the thesis. These two manuals used in concert will provide base fitness information throughout the research.

The *Fitness Professional's Guide to Musculoskeletal Anatomy and Human Movement*, by Golding and Golding, and its associated computer software, will be one of the most used sources in the entire study to analyze specific exercises and movements at

the muscular and skeletal level in order to conduct a comparison between specific APFT events and combat tasks. Although this work provides specifics on musculature and some skeletal usage, it does not discuss all the elements of fitness. Other sources, professional journals, will be presented as needed to support or supplement the assessments of this work. Due to the high availability of these journal articles, it is impossible to cover them all in depth here. Specific articles will be discussed throughout the analysis portion of the thesis.

This chapter has reviewed a wide range of the current literature on the subject of training in general, and physical training in particular, within the Army. It discusses the current attitudes reflected by unit level leaders, current military manuals and historical and current examples. It also presents the same issues that the Marine Corps is facing in today's environment. The most important literature discussed in this chapter is the actual body of work that will be used to conduct the actual analysis portion of the thesis. The next chapter the will describe the analysis framework used for this study.

CHAPTER 3

RESEARCH DESIGN

Chapter One discussed the argument for conducting combat focused physical training and testing. It also pointed out that the Army has no formal method to test physical readiness specifically for combat. The current Army Physical Fitness Test (APFT) is only a measure of general wellness. The background information in the literature review chapter seems to uphold the views that the Army needs to conduct battle focused training (BFT) and battle focused physical training (BFPT). Many leaders actively fighting in Afghanistan and Iraq echo this belief. This chapter explains the research methodology used for this study.

The research methodology consists of four stages. The first stage will conduct an analysis of the elements of the current APFT (pushups, sit-ups, and two mile run) on the basis of body actions required to conduct the activities. The second stage will identify the combat oriented tasks covered in the TRADOC (Training and Doctrine Command) PT Manual, and then analyze them based on body actions in the same manner as the APFT. The third stage of the research will attempt to identify a set of combat physical tasks based on other officers' experiences in the Global War on Terror (GWOT), by surveying the majors of Intermediate Level Education (ILE) Class 08-01. Finally, the fourth stage of the research will analyze the combat tasks resulting from the third stage and then conduct a comparison between the body actions of the current APFT, the TRADOC tasks, and these combat tasks. This analysis will result in recommendations for developing testing procedures to test any shortfalls of the APFT.

The first stage of the research will analyze the pushup, sit-up, and two mile run exercises by body actions, and associated muscles and how they are used to perform these exercises (See Table 1.) The body actions will be analyzed according to whether they are associated with strength or endurance and whether they involve isometric, concentric, or eccentric muscular contractions.

Table 1. APFT Analysis Methodology

	Body Action	Isometric	Eccentric	Concentric	Endurance	Strength
Pushup	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Sit-up	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Run	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No

The second stage of the research will then analyze the combat oriented tasks found in chapter thirteen of the TRADOC PT Manual, which will be inferred as Army-wide guidance toward what combat tasks Soldiers should be able to perform. These tasks will also be analyzed on the basis body actions and associated muscles and how they are used. Specifically, these tasks include: lifting from the ground, lifting overhead, pushing, rotation, jumping and landing, lunging, marching and running (See Table 2.) These TRADOC identified tasks will be analyzed using the same method as the APFT events. They will be broken down into body actions used to conduct the exercise. These body actions will be described as being associated with strength or endurance and the type of muscle contractions utilized.

Table 2. TRADOC Task Analysis Methodology

	Body Action	Isometric	Eccentric	Concentric	Endurance	Strength
Lift from the Ground	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Lift Overhead	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Pushing	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Rotation	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Jumping and Landing	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Lunging	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Marching	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Running	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No

The third stage of the research will be the application of an electronic survey of ILE students to identify another set of applicable combat tasks based on their combat experience and or professional opinion. This survey is a simple device which asks the user to pick up to six physical tasks that they would consider important and necessary for combat mission accomplishment based on their experiences, or impressions if they are not combat veterans, of Iraq and Afghanistan. The survey contains twenty two tasks to choose from, as well as the opportunity to write in a response. These choices are derived from the eight tasks cited in the TRADOC manual. Fourteen tasks were derived from views expressed by Soldiers in theater (as expressed on the Center for Army Lessons Learned (CALL) and Company Command web sites.) This survey attempts to identify,

from the "user level," six tasks that leaders consider important for a Soldier to be able to physically accomplish in combat. This web based survey is represented in Appendix A.

The fourth stage of the research analyzes the "combat tasks" identified by the survey. These tasks are analyzed on the same basis as the APFT exercises and the TRADOC list of tasks (See Table 3.) All six tasks will be analyzed by the body actions and associated muscles required to perform them. The body actions will be characterized as endurance or strength based and whether they are generally isometric, eccentric, or concentric muscular contractions. At this point in the research method there will be a completed muscular analysis of the APFT events, the TRADOC tasks, and "combat tasks" identified by ILE majors.

Table 3. Combat Task Analysis Methodology

	Body Action	Isometric	Eccentric	Concentric	Endurance	Strength
Task #1	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Task #2	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Task #3	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Task #4	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Task #5	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
Task #6	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No

The conclusion of the fourth stage of the research will compare the analysis of the APFT events, the TRADOC tasks, and the "combat tasks." This will be accomplished by

simply comparing the results of the APFT analysis, first to the TRADOC tasks (the Army guidance) and then to the "combat tasks" (the current and future Army leaders' opinions) (See Table 4.) For example, each body action required to conduct the each of the TRADOC task "Lift from the ground" will be compared to those required to conduct the pushup. Any tasks that are used for both, will then be compared to how they are used; endurance, strength, isometric, eccentric, or concentric. This same method will be utilized to compare the APFT to the "combat tasks." The conclusion of this stage of the research will identify what, if any, body actions utilized for the APFT are utilized for the TRADOC tasks or the combat tasks. Further, the shortfalls can be specifically identified in order that further research can make up these shortfalls.

Table 4. APFT Comparison to TRADOC Tasks and Combat Tasks Methodology

	Body Action	Isometric	Eccentric	Concentric	Endurance	Strength
Lift from the Ground	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No

=

	Body Action	Isometric	Eccentric	Concentric	Endurance	Strength
Pushup	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No

=

	Body Action	Isometric	Eccentric	Concentric	Endurance	Strength
Task #1	#1	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No
	#2	Yes or No	Yes or No	Yes or No	Yes or No	Yes or No

There are several limitations associated with this study. There are numerous articles, papers, and personal experiences that identify multiple physical attributes that

Soldiers need to possess in combat, as evidenced by the CALL and Company Command web sites. The major problem is the identification of a manageable number of these physical tasks for which the Army needs to train and test. This study will limit the list of tasks to those identified in the TRADOC PT Manual and the peer survey described earlier in this chapter. A limitation associated with these tasks is the lack of specific data resulting from other studies on some of the more complex "combat tasks." These tasks will be evaluated only on required body actions and their associated muscles and how they are used. Finally, the population of the survey will only include Army majors in Command and General Staff College, Class 08-01.

Chapter four will conduct the analysis as previously described in this chapter. This analysis will explore, on a muscular level, what the APFT actually measures. It will also show what is required, on a muscular level, what is required of an individual conducting the TRADOC tasks and the set of "combat tasks." It will show if the APFT is a valid measure of the muscular usage required to conduct either of these sets of tasks. The end product will show what shortfalls are inherent to the APFT, if any. These shortfalls will be used as a basis for recommendations for the future of the APFT.

CHAPTER 4 ANALYSIS

Section 1

The current Army Physical Fitness Test (APFT) is a measure of general well-being, not a test of combat readiness. Many professional combat leaders have expressed a feeling of the need to train for combat, in both a general sense and specifically in physical training. These young Non-Commissioned Officers (NCOs) conducting operations in Iraq and Afghanistan, the company grade officers who lead these NCOs, as well as senior leaders both past and present all offer proof of this attitude. These same beliefs seem also to be held by the Marine Corps, as evidenced by their current research into their own Physical Fitness Test (PFT.) The Marine Corps is currently working toward adopting a supplementary Combat Fitness Test (CFT), in addition to their current fitness test (Tilghman,2008.)

The current APFT is not an accurate measure of combat fitness. This chapter will prove or disprove this notion by conducting a comparative analysis of the muscles used in the current APFT and the combat tasks that the Army identifies in the Training and Doctrine Command (TRADOC) Physical Fitness (PT) Manual. The first step in this process will be to break down the APFT events, using the Exercise Explorer software, mentioned in the literature review, to develop a list of all the body actions and associated muscles used to conduct each event. The same will be done for the tasks identified in the TRADOC PT manual. The analysis will also introduce six *combat tasks* which are the results of a survey of almost 600 Intermediate Level Education (ILE) majors and their opinions of Soldiers' physical requirements in combat. Once all of these sets of physical

tasks have been broken down to the muscular level, they will be compared to detect any correlation.

According to FM 21-20, the APFT is a three event test which assesses muscular and cardio-respiratory endurance. The events are conducted in a specific order: pushups, sit-ups, and the two mile run, with no exception to the specified order. At the beginning of each, Soldiers are read the standards for conduct and evaluation of each event (U.S. Department of the Army, 1998, 14-10.) These standard describe: 1. What the Army expects to measure with the exercise; and, 2. The physical description of the conduct of the exercise. These published standards will be used to develop a basis for analysis. Exercise Explorer Software will then be used to identify the body motions and muscles used.

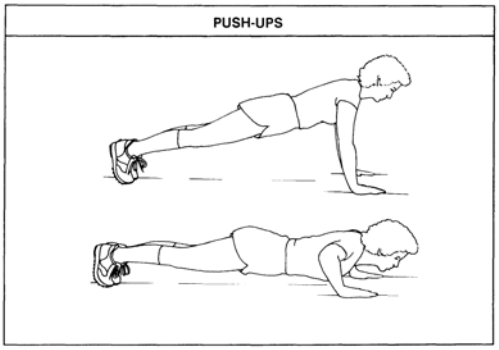
Before beginning the analysis there are several terms that have to be understood throughout this chapter as they will describe how the muscles are used: endurance, strength, isometric, eccentric, and concentric. Muscular endurance is the ability of a muscle or muscle group to do repeated contractions against a less-than-maximum resistance for a given time (U.S. Department of the Army, 1998, 3-1.) Muscular strength is greatest amount of force that a muscle or muscle group can exert in a single effort (U.S. Department of the Army, 1998, 3-1.) Isometric contraction is when a muscle remains at a fixed length (Faulkner, 2003, 455) or when it produces force but there is no change in the angle of the joint (Department of the Army, 1998, 3-1.) Concentric contraction refers to when the muscle shortens (Faulkner, 2003, 455) and is the positive phase of movement (Department of the Army, 1998, 3-1.) Eccentric contraction is the negative phase (U.S. Department of the Army, 1998, 3-1) when the muscle lengthens

(Faulkner, 2003, 455.) These terms will be used throughout the chapter to describe body motions and will be used specifically during the comparison between the APFT, the TRADOC tasks, and the "combat tasks."

The pushup is the first exercise of the APFT. The following is an excerpt of specific instructions, with associated image (See Figure 1) found in FM 21-20 from which Soldiers are briefed before execution of the exercise:

> "THE PUSHUP EVENT MEASURES THE ENDURANCE OF THE CHEST, SHOULDER, AND TRICEPS MUSCLES……ASSUME THE FRONT LEANING REST POSITION BY PLACING YOUR HANDS WHERE THEY ARE COMFORTABLE….YOUR FEET MAY BE TOGETHER OR UP TO 12 INCHES APART. WHEN VIEWED FROM THE SIDE YOUR BODY SHOULD FORM A GENERALLY STRAIGHT LINE FROM YOUR SHOULDERS TO YOUR ANKLES…BEGIN THE PUSH-UP BY BENDING YOUR ELBOWS AND LOWERING YOUR ENTIRE BODY AS A SINGLE UNIT UNTIL YOUR UPPER ARMS ARE AT LEAST PARRALLEL TO THE GROUND….THEN RETURN TO THE STARTING POSITION BY RAISING YOUR ENTIRE BODY…." (U.S. Department of the Army, 1998, 14-11-14-12)

There are two points to be derived from this description. The first point is that the stated purpose of the exercise is to measure the "endurance of the chest, shoulder, and triceps muscles." Endurance is defined in FM 21-20 as the ability to conduct repeated contractions against a less-than-maximum resistance for a given time. The second is the physical description of the conduct of the exercise, which can be used to determine associated body actions. These body actions can help to identify the muscles used to perform the exercise.



The Pushup
Source: Pushup (FM 21-20, U.S. Department of the Army, 1998),14-12

Because the Exercise Explorer software already has the basic pushup in its catalog of exercises no interpolation, as will be required later in the chapter for non-standard activities, was needed to identify body actions for the pushup. According to the Exercise Explorer software, there are eight body actions used to conduct the pushup exercise. These actions as are:

- Arm Flexion – taking the arms upward in front or from the sides to overhead (Exercise Explorer, 2006, exercise analyzer function)
- Arm Horizontal Adduction – moving the arms horizontally from the sides to the front of the chest (Exercise Explorer, 2006, exercise analyzer function.)
- Elbow Extension – straightening the elbow from a flexed position (Exercise Explorer, 2006, exercise analyzer function.)
- Head Extension – moving the head backwards, chin away from chest (Exercise Explorer, 2006, exercise analyzer function.)
- Spine Extension – straightening the spine from a hunched over position

(Exercise Explorer, 2006, exercise analyzer function.)

- Hip-Leg Flexion – moving the leg forward toward the front (Exercise Explorer, 2006, exercise analyzer function.)
- Scapula Abduction – taking the shoulder blades apart, as when hunching the shoulders forward (Exercise Explorer, 2006, exercise analyzer function.)
- Knee Flexion – bending the leg at the knee. (Exercise Explorer, 2006, exercise analyzer function.)

Exercise Explorer breaks these actions down by how they are used and associated muscle contractions. Arm flexion, arm horizontal adduction, elbow extension scapula abduction, are used to conduct the "let down" motion and represent eccentric muscular contraction (Exercise Explorer, 2006, exercise analyzer function.) During the "push up" portion of the exercise these same muscle actions would represent, by definition, concentric muscular contractions (Exercise Explorer, 2006, exercise analyzer function.) Head extension, spine extension, hip-leg flexion, and knee flexion are body stabilization functions and represent isometric muscular contractions (Exercise Explorer, 2006, exercise analyzer function.)

Within each of the muscular actions required to conduct the pushup exercise, there are numerous individual muscles that are used. Exercise Explorer breaks each of these body actions down into the associated muscles. The four concentric and eccentric contraction muscles, by body action are shown in Table 5. The associated muscles with the four isometric body actions for the pushup exercise are shown in Table 6. This list provides a basis upon which to conduct the comparison against the TRADOC identified

tasks and later the ILE major combat tasks, not only by individual muscle, but also by its associated use and body actions.

Table 5. Pushup Concentric and Eccentric Body Actions Analysis

Arm Flexion
Biceps Brachii
Coracobrachialis
Deltoid Anterior
Pectoralis Major

Arm Horizontal Abduction
Coracobrachialis
Deltoid Anterior
Pectoralis Major
Latissimus Dorsi

Scapula Abduction
Serratus Anterior

Elbow Extension
Anconeus
Extensor Carpi Radialis Brevis
Extensor Carpi Radialis Longus
Extensor Carpi Ulnaris
Extensor digiti Minimi
Extensor Digitorum
Triceps Brachii

Source: Pushup (E2 Systems Inc., 2006),exercise analysis function

Table 6. Pushup Isometric Body Actions Muscle Usage

Head extension
Longissimus Capitis
Obliquuus Capitis Superior
Rectus Capitis Posterior (major)
Rectus Capitis Posterior (minor)
Spinalis Capitis
Splenius Capitis
Splenius Cervicis
Trapezius

Knee Flexion
Biceps Femoris
Gastrocnemius
Gracilis
Plantaris
Popliteus
Sartorius
Semimembranosus
Semitendinosus

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Hip-Leg Flexion
Abductor Brevis
Abductor Longus
Abductor Magnus
Gluteus Medius
Gluteus Minimus
Gracilis
Iliacus
Pectineus
Psoas Major
Psoas Minor
Rectus Femoris
Sartorius
Tensor Fascia Latae

Source: Pushup (E2 Systems Inc., 2006),exercise analysis function

Independent articles in scientific journals were used to lend credence to the Exercise Explorer data. An article in *The American Journal of Sports Medicine,* specifically address the use of the pushup as a rehabilitative exercise for strengthening the serratus anterior, which is previously identified as a key muscle for eccentric and concentric contraction during the pushup, in patients with shoulder dysfunctions (Ludewig et al. 2004, 484-485.) Another article in *The Journal of Strength and Conditioning Research* support the high level of activation of the pectoralis major and the triceps brachii and suggest that close-hand pushups are more difficult than wide-arm pushups (Cogley et al. 2005, 630), which is problematic for standardization in that FM 21-20 does not specify a close or wide arm position. In *Medicine & Science in Sports & Exercise*, researchers specifically identify usage of the rectus abdominis, external oblique, internal oblique, latissimus dorsi, and erector spinae muscles used for body stabilization along with the pectoralis major, triceps brachii, biceps brachii, and deltoid muscles for body stabilization (Freeman et al. 2006, 572.)

By using the Exercise Explorer software, a list of the body actions and muscles used during the pushup exercise can be developed. This base list was compared to scientific journal articles in order to substantiate the scientific credibility of this list of muscles used. These body actions and muscles were then designated as eccentric and or concentric or isometric during the exercise. Based on this information, it can be said with a high degree of confidence, that the pushup does meet the APFT's intent to measure the endurance of the chest, shoulder, and tricep muscles. It may also measure the strength of certain isometrically contracted muscles during the spine extension which is an associated action of body stabilization. With no supporting documentation, the knee

flexion, hip-leg flexion, and head extension will no longer be considered elements of the pushup throughout the rest of the thesis. Table 7 represents the muscular usage attributed to the pushup exercise as it will be understood throughout the rest of this chapter:

Table 7. Final Pushup Body Action Analysis

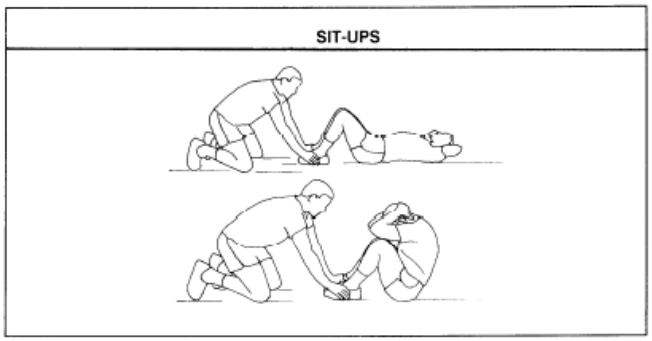
PUSHUP	Isometric	Eccentric	Concentric	Endurance	Strength
Arm Flexion		X	X	X	
Arm Horizontal Adduction		X	X	X	
Elbow Extension		X	X	X	
Spine Extension	X				
Scapula Abduction		X	X	X	

The sit-up is the second exercise of the APFT. As with the pushup, the following is an excerpt of specific instructions, with associated image (See Figure 2) found in FM 21-20 from which Soldiers are briefed before execution of the exercise:

> "THE SIT-UP EVENT MEASURES THE ENDURANCE OF THE ABDOMINAL AND HIP FLEXOR MUSCLES…ASSUME THE STARTING POSITION BY LYING ON YOUR BACK WITH YOUR KNEES BENT AT A 90-DEGREE ANGLE. YOUR FEET MAY BE TOGETHER OR UP TO TWELVE INCHES APART…. THE HEEL IS THE ONLY THING THAT MUST STAY IN CONTACT WITH THE GROUND. YOUR FINGERS MUST BE INTERLOCKED BEHIND YOUR HEAD….BEGIN RAISING YOUR UPPER BODY FORWARD TO, OR BEYOND, THE VERTICAL POSITION….LOWER YOUR BODY UNTIL THE BOTTOM OF YOUR SHOULDER BLADES TOUCH THE GROUND." (U.S. Department of the Army, 1998, 14-14-14-16.)

There are two points to be derived from this description. The first is that the stated purpose of the exercise is to measure the "endurance of the abdominal and hip flexor

muscles." Again, the FM 21-20 definition for endurance should be applied. A second piece is the physical description of the conduct of the exercise which can be used to determine associated body actions. These body actions can help to identify the muscles used to perform the exercise.



The Sit-up
Source: Sit-up (FM 21-20, U.S. Department of the Army, 1998),14-14

Because the Exercise Explorer software does not have the APFT's version of the sit-up in its catalog of exercises, some interpolation based on the verbal and visual description was required to identify body actions associated with the exercise. First, the motions chest up and chest down, associated with the actual sit-up movement, were used to determine the body actions and associated muscles. According to the Exercise Explorer software, there are two body actions associated with these motions:

- Spine Flexion – bending the spine forward to a hunched over position (Exercise Explorer, 2006, exercise analyzer function.)
- Head Flexion – bringing the chin toward the chest (Exercise Explorer, 2006, exercise analyzer function.)

Further body motions based on the FM 21-20 description and instructions are:

- Hip-leg Flexion – moving the leg forward to the front (Exercise Explorer, 2006, body action analyzer function.) (visually depicted in Exercise Explorer as bending at the waist) which is based on the FM 21-20 instructions, "ASSUME THE STARTING POSITION BY LYING ON YOUR BACK WITH YOUR KNEES BENT AT A 90-DEGREE ANGLE…BEGIN RAISING YOUR UPPER BODY FORWARD…" (U.S. Department of the Army, 1998, 14-15.)
- Arm Horizontal Adduction – moving the arms horizontally from the sides to the front of the chest, (Exercise Explorer, 2006, body action analyzer function.) based on the graphic representation of the exercise and the instructions, "YOUR FINGERS MUST BE INTERLOCKED BEHIND YOUR HEAD..." (U.S. Department of the Army, 1998, 14-15.)
- Elbow Flexion – bending the arm at the elbow (Exercise Explorer, 2006, body action analyzer function.) based on the graphic representation of the exercise and the instructions "YOUR FINGERS MUST BE INTERLOCKED BEHIND YOUR HEAD…"(U.S. Department of the Army, 1998, 14-15.)
- Knee Flexion – bending the leg at the knee (Exercise Explorer, 2006, body action analyzer function.) based on the graphic representation and the instructions, "ASSUME THE STARTING POSITION BY LYING ON YOUR BACK WITH YOUR KNEES BENT AT A 90-DEGREE ANGLE…"(U.S. Department of the Army, 1998, 14-15.)

- Wrist Flexion – curling the wrist moving the hand in the direction of the palm (Exercise Explorer, 2006, body action analyzer function.) based on the graphic representation and the instructions, "YOUR FINGERS MUST BE INTERLOCKED BEHIND YOUR HEAD…"(U.S. Department of the Army, 1998, 14-15.)
- Finger Flexion – curling the fingers as when making a fist (Exercise Explorer, 2006, body action analyzer function.) based on the same information as wrist flexion from the FM 21-20 description (U.S. Department of the Army, 1998, 14-15.).

All three types of muscle contractions are used in the execution of the sit-up exercise based on the definitions (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1.) Exercise Explorer characterizes the actions of spine flexion and head flexion as concentric, or shortening of muscles, on the way up and eccentric, or lengthening of muscles, on the way down. The hip-leg flexion action, based on the conduct of the exercise provided in FM 21-20 is also by definition, concentric on the upward movement and eccentric on the downward. Based on the definition of isometric contraction it is reasonable to assume, again based on the description provided in FM 21-20 for the sit-up exercise, arm horizontal adduction, wrist flexion, finger flexion, and knee flexion fall into this category.

Within each of these identified muscular actions required to conduct the sit-up exercise, there are numerous individual muscles that are used. Exercise Explorer breaks these body actions down into these associated muscles. The concentric and eccentric contraction muscles, by body action are shown in Table 8. The associated muscles with

the isometric body actions for the sit-up exercise are shown in Table 9. As with the pushup exercise, this list establishes a basis for comparison, by body action, to both the TRADOC identified tasks and the combat tasks from the survey.

Table 8. Sit-up Concentric and Eccentric Body Actions Muscle Usage

Hip-leg flexion
Abductor Brevis
Abductor Longus
Abductor Magnus
Gluteus Medius
Gluteus Minimus
Gracilis
Iliacus
Pectineus
Psoas Major
Psoas Minor
Rectus Femoris
Sartorius
Tensor Fascia Latae

Spine Flexion
External Oblique Abdominal
Internal Oblique Abdominal
Longus Colli (inferior oblique)
Longus Colli (superior oblique)
Longus Colli (vertical)
Rectus Abdominis
Scalenus Anterior
Scalenus Posterior

Head Flexion
Longus Capitis
Rectus Capitis Anterior
Sternocleidomastoid

Source: Sit-up (E2 Systems Inc., 2006),body action analysis function

Table 9. Sit-up Isometric Body Actions Muscle Usage

Elbow Flexion
Biceps Brachii
Brachialis
Brachiordialis
Flexor Carpi Radialis
Flexor Carpi Ulnaris
Flexor Digitorum Superficialis
Palmaris Longus
Pronator Teres
Supinator

Finger Flexion
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Lumbricals
Palmar Interossei
Abductor Digiti Minimi
Flexor Digiti Minimi Brevis
Opponens Digiti Minimi

Wrist Flexion
Flexor Carpi Radials
Flexor Carpi Ulnaris
Palmaris Longus
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Flexor Pollicus Longus

Knee Flexion
Biceps Femoris
Gastrocnemius
Gracilis
Plantaris
Popliteus
Sartorius
Semimembranosus
Semitendinosus

Arm Horizontal Adduction
Coracobrachialis
Pectoralis Major
Deltoid Anterior
Latissimus Dorsi

Source: Sit-up (E2 Systems Inc., 2006),body action analysis function

Two different articles in *Medicine &Science in Sports & Exercise* indicate the stresses placed on the trunk, especially the abdominal group, and leg muscles for several sit-up-type exercises. In one article the authors espouse the view that these type exercises could be useful for conditioning the leg muscle groups as well as the abdominals (Ricci and Figura, 1981, 55-58) Another article for *Medicine & Science in Sports & Exercise* discusses the high use of the Psoas muscles, commonly referred to as the hip flexors, during sit-up type exercises (Juker et al. 1998, 305-309.) Finally, an article in *Physical Therapy* specifically measure the percentage of contraction for the upper rectus abdominis, lower rectus abdominis, external obliques, internal obliques, latissimus dorsi, lumbar paraspinals, and rectus femoris (Escamilla et al. 2006, 664.) Due to the lack of evidence supporting the muscle activity of the supporting body actions, wrist flexion, finger flexion, knee flexion, elbow flexion, and arm horizontal adduction, these will not be used further to characterize the sit-up.

By using the Exercise Explorer software, a base model of the body actions and muscles used during the sit-up exercise was developed. This base was then compared to scientific journal articles in order to substantiate its credibility. Based on this information, it can be said with a high degree of confidence, that the sit-up does meet the intent of the APFT to measure the endurance of the hip flexor and abdominal muscles. It may measure the muscles used in the isometric body actions with some degree of confidence. However, for the purpose of this thesis, the hip-leg flexion and spine flexion and associated muscles will be the only two body actions that will be used, as they could be substantiated with supporting evidence. Table 10 represents the muscle usage that will be considered to be associated with the sit-up exercise throughout the rest of this chapter:

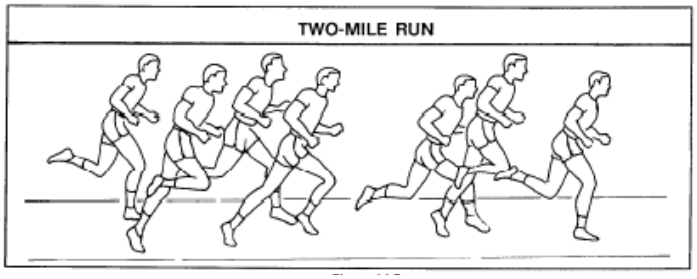
Table 10. Final Sit-up Body Action Analysis

SIT-UP	Isometric	Eccentric	Concentric	Endurance	Strength
Hip-Leg Flexion		X	X	X	
Spine Flexion		X	X	X	

The two mile run is the third event in the APFT. The following excerpt, with associated image (See Figure 3), can be found in FM 21-20, from which Soldiers are briefed before execution of the exercise:

> "THE TWO-MILE RUN IS USED TO ASSESS YOUR AEROBIC FITNESS AND YOUR LEG MUSCLES' ENDURANCE...YOU ARE BEING TESTED ON YOUR ABILITY TO COMPLETE THE 2-MILE COURSE IN THE SHORTEST TIME POSSIBLE…ALTHOUGH WALKING IS AUTHORIZED IT IS STRONGLY DISCOURAGED." (Department of the Army, 1998, 14-17-14-18.)

As with the previous two events, a similar set of points may be derived from this description. The first is that the stated purpose of the exercise is to measure the "leg muscles' endurance." Once again, the FM 21-20 definition for endurance should be applied. Secondly, the physical description of the conduct of the exercise can again be used to determine associated body actions. These body actions can help to identify the muscles used to perform the exercise.



The Run
Source: Run (FM 21-20, U.S. Department of the Army, 1998),14-17

Because the Exercise Explorer software does have running in its catalog of exercises, no interpolation was required to identify body actions associated with the exercise. According to the Exercise Explorer software, there are thirteen body actions required to conduct the run event of the APFT:

- Knee Extension – straightening the leg at the knee (Exercise Explorer, 2006, exercise analyzer function.)
- Ankle Plantar Flexion – taking the toes away from the shin (Exercise Explorer, 2006, exercise analyzer function) (visually depicted as the act of bending the ankle at the joint.)
- Hip-Leg Extension – moving the leg backward from being in front (Exercise Explorer, 2006, exercise analyzer function.)
- Spine Rotation – rotating the spine to the right or left (Exercise Explorer, 2006, exercise analyzer function.)
- Arm Extension – bringing the arms downward, to the sides, from overhead (Exercise Explorer, 2006, exercise analyzer function.)
- Ankle Dorsal Flexion – bringing the toes toward the shin (Exercise

Explorer, 2006, exercise analyzer function) (visually depicted as the act of bending the ankle at the joint.)

Further body actions that are used to conduct the run and have already been defined during examination of the pushup, are arm flexion, head extension, elbow extension, knee flexion, and spine extension. The last body action, hip-leg extension, was identified and defined in both the pushup and sit-up analyses.

Exercise Explorer characterizes the actions of spine extension and head extension as body stabilization and an isometric muscle contraction. It further designates arm flexion, elbow flexion, knee extension, ankle plantar flexion, hip-leg extension, and spine rotation as being associated with the leg moving back and the arm forward motion of the run. Arm extension, elbow extension, knee flexion, ankle dorsal flexion, hip-leg flexion, and spine rotation are associated with the leg moving forward and the arm moving back during execution of the event(Exercise Explorer, 2006, exercise analyzer function.) By definition of isometric contraction, it is reasonable to assume that the spine and head extension are indeed isometric (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1.) The other body motions are associated, by these same definitions, with both eccentric and concentric contractions.

Within each of these identified muscular actions required to conduct the run exercise, there are numerous individual muscles that are used. Exercise Explorer breaks these body actions down into the associated muscles. Body actions and associated muscles which contract concentrically and eccentrically to perform the “leg backward and arm forward” motions are shown in Table 11. Body actions and associated muscles which contract concentrically and eccentrically to perform the “leg forward and arm

backward" motions are shown in Table 12. The body actions and associated muscles for body stabilization identified by the Exercise Explorer are shown in Table 13. These lists continue to establish that from which to conduct the comparison against the TRADOC identified tasks and later the ILE major combat tasks, by individual muscle, and also by the associated use and body actions.

Table 11. Concentric and Eccentric Contractions "leg back and arms forward" Analysis

Elbow Flexion
Biceps Brachii
Brachialis
Brachiordialis
Flexor Carpi Radialis
Flexor Carpi Ulnaris
Flexor Digitorum Superficialis
Palmaris Longus
Pronator Teres
Supinator

Ankle Plantar Flexion
Flexor Digitorum Longus
Flexor Hallucis Longus
Gastrocnemius
Peroneus Brevis
Peroneus Longus
Plantaris
Soleus
Tibialis Posterior

Spine Rotation
External Oblique Abdominal
Internal Oblique Abdominal
Multifidus
Rotatores
Scalenus Anterior
Scalenus Medius
Scalenus Posterior
Semispinalis Cervicis
Semispinalis Thoracis

Knee Extension
Rectus Femoris
Vastus Intermedius
Vastus Lateralis
Vastus Medialis

Hip-Leg Extension
Abductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Arm Flexion
Biceps Brachii
Coracobrachialis
Deltoid Anterior
Pectoralis Major

Source: Run (E2 Systems Inc., 2006),exercise analysis function

Table 12. Concentric and Eccentric Contractions “leg forward and arm back” Analysis

Hip-Leg Flexion
Abductor Brevis
Abductor Longus
Abductor Magnus
Gluteus Medius
Gluteus Minimus
Gracilis
Iliacus
Pectineus
Psoas Major
Psoas Minor
Rectus Femoris
Sartorius
Tensor Fascia Latae

Ankle Dorsal Flexion
Extensor Digitorum Longus
Extensor Hallucis Longus
Peroneus Tertius
Tibialis Anterior

Spine Rotation
External Oblique Abdominal
Internal Oblique Abdominal
Multifidus
Rotatores
Scalenus Anterior
Scalenus Medius
Scalenus Posterior
Semispinalis Cervicis
Semispinalis Thoracis

Arm Extension
Deltoid Posterior
Latissimus Dorsi
Subscapularis
Teres Major
Teres Minor
Triceps Brachii

Elbow Extension
Anconeus
Extensor Carpi Radialis Brevis
Extensor Carpi Radialis Longus
Extensor Carpi Ulnaris
Extensor digiti Minimi
Extensor Digitorum
Triceps Brachii

Knee Flexion
Biceps Femoris
Gastrocnemius
Gracilis
Plantaris
Popliteus
Sartorius
Semimembranosus
Semitendinosus

Source: Run (E2 Systems Inc., 2006),exercise analysis function

Table 13. Run Body Stabilization Body Actions Muscle Usage

Head Extension
Longissimus Capitis
Obliquuus Capitis Superior
Rectus Capitis Posterior (major)
Rectus Capitis Posterior (minor)
Spinalis Capitis
Splenius Capitis
Splenius Cervicis
Trapezius

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Source: Run (E2 Systems Inc., 2006),exercise analysis function

As before, articles in scientific journals were used to lend support to this Exercise Explorer data on the body motions associated with the run. An article in *Clinics in Sports Medicine,* provides a relatively thorough and understandable explanation of the differences between walking, running, and sprinting. Generally, the body lowers its center of gravity as it increases speed from walking to running to sprinting. As these actions take place there is an associated joint extension as the stride lengthens which has implications on the importance of flexibility. Also, probably most importantly, electromyography shows that with increased speed, the individual leg muscles show increased activity for a longer portion of the gait. In short, increased speed means an increased proportion of muscle usage (Thorardson, 1997, 242-243.) The importance of these differences will become more readily apparent later in this chapter. This article supports the Exercise Explorer assertion that rotation, hip-leg flexion, knee flexion and ankle dorsal flexion are components of running. He also addresses the use of most of the major leg muscle groups identified by the program and describes how some muscles can contract eccentrically and concentrically at the same time with increased speed (Thorardson, 1997, 245.)

Another article in *The American Journal of Sports Medicine,* illustrates the same conclusions as Thordarson. There are several major differences between walking, running, and sprinting. These differences are the increase in muscle usage as a person speeds up, changes in joint range of motion, the differences in how the foot makes contact with the ground, and a body's center of gravity (Mann and Hagy, 1980, 346.) Within the article, these authors also lend support to the Exercise Explorer by identifying

the hip-leg flexion and extension, knee flexion and extension, and ankle plantar and dorsal flexion body motions as well as most of the associated muscle groups. Both articles tend to show that the muscles associated with the identified body motions undergo eccentric and concentric contraction.

The Exercise Explorer software developed a base model of the body actions and muscles used during the run. This base was then compared to journal articles in order to substantiate its credibility. Based on this information, it can be said with a high degree of confidence, that the run does meet the intent of the APFT to measure the endurance of the leg muscles. Also, the stability actions of running are associated with torso rotation (Kumar, Narayan, and Zedka, 1996, 1503-1505) muscles which are part of spine rotation. It may also measure the muscles used in the isometric body stabilization actions of head and spine extension and some muscular output associated with the arm forward and backward movement of running. However, since no further evidence could be found to substantiate these last two, they will not be used further in the thesis. Instead, the run will be used as a measure of leg muscles and torso muscles associated with body rotation. The following chart represents muscle usage associated with the run event and will be used for the remainder of the chapter as shown in Table 14.

Table 14. Final Run Body Action Analysis

RUN	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension		X	X	X	
Ankle Plantar Flexion		X	X	X	
Hip-Leg Extension		X	X	X	
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	

Each APFT event states that it is intended to measure a specific element of a couple of specific muscle groups. The intent of the pushup is to measure the endurance of the chest, tricep, and shoulder muscles. The sit-up's purpose is to measure the endurance of the abdominal and hip-flexor muscles. The run is meant to measure endurance of the leg muscles (U.S. Department of the Army, 1998, 14-11-14-18. Given the FM 21-20 definition of endurance, and the information gained from the commercial Exercise Explorer in combination with professional scientific experimentation, it was determined that the APFT events do measure what they intend. Table 15 graphically depicts what the APFT measures at the muscular level. The exercises are almost primarily focused on measures of eccentric and concentric contraction at the muscular level. All of the exercises are focused on endurance, rather than strength. This chart will be used later as APFT events are compared to the TRADOC tasks and eventually the tasks which resulted form the CGSC survey.

Table 15. Final APFT Muscular Usage Chart

	Pushup	Situp	Run	Isometric	Eccentric	Concentric	Endurance	Strength
Arm Flexion	X				X	X	X	
Arm Horizontal Adduction	X				X	X	X	
Elbow Extension	X				X	X	X	
Spine Extension				X				
Scapula Abduction	X				X	X	X	
Hip-Leg Flexion		X			X	X	X	
Spine Flexion		X			X	X	X	
Knee Extension			X		X	X	X	
Ankle Plantar Flexion			X		X	X	X	
Hip-Leg Extension			X		X	X	X	
Spine Rotation			X		X	X	X	
Knee Flexion			X		X	X	X	
Ankle Dorsal Flexion			X		X	X	X	

Section 2

This section will analyze the combat tasks identified in the TRADOC PT manual. The following TRADOC tasks will be analyzed using the same methodology as the APFT events: lifting from the ground, lifting overhead, push, pulling or climbing, rotation, jumping and landing, lunging, marching, and running and changing direction. Upon completion, the TRADOC tasks will be compared to the APFT events to ascertain if there is any similarity between the two.

The first task identified in the TRADOC PT manual is lifting from the ground. The following is the written description. For the associated image see Figure 4.

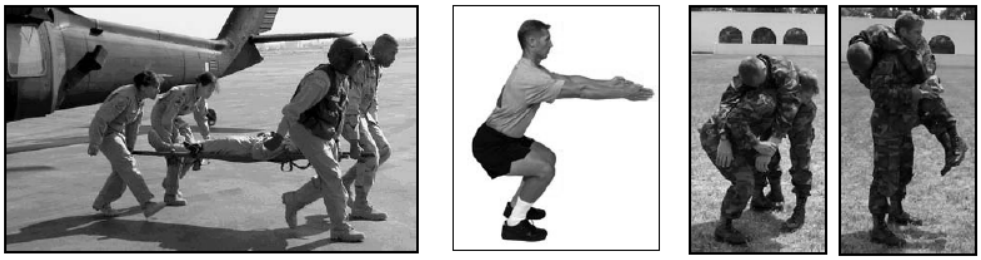
> "Power the lift with the legs, not the back. Then continue to bend at the hips and knees to lower the body. In order to protect the back, keep the hips set and the abdominal muscles tight throughout the lift. Keep the load close to the body from start to finish. When Soldiers must turn under load, do so by pivoting the feet rather than twisting the trunk." (U.S. Department of the Army, 2003, 161.)

This visual and written physical description of the conduct of the activity can be used to determine associated body actions. These body actions can help to identify the muscles used to perform the exercise. Because the Exercise Explorer software does not have this exact physical task in its catalog of exercises some interpolation was required to identify body actions for the task. In this case the "deadlift" exercise was used as the base due to its similarity to the description of this task in the manual. The associated body actions for the "deadlift" as described and defined by Exercise Explorer are:

- Knee Extension – straightening the leg at the knee (Exercise Explorer, 2006,

exercise analyzer function.)

- Hip-Leg Extension – moving the leg backward from being in front (Exercise Explorer, 2006, exercise analyzer function.)
- Spine Extension – straightening the spine from a hunched over position (Exercise Explorer, 2006, exercise analyzer function.)
- Wrist Flexion – curling the wrist moving the hand in the direction of the palm (Exercise Explorer, 2006, exercise analyzer function.)
- Finger Flexion – curling the fingers as when making a fist (Exercise Explorer, 2006, exercise analyzer function.)
- Thumb Flexion – curling the thumb as when gripping (Exercise Explorer, 2006, exercise analyzer function.)
- The following body action is not associated with the Exercise Explorer's "deadlift" exercise but encompasses the majority of the abdominal muscles, which the TRADOC manual specifically discusses in its description of this task (U.S. Department of the Army, 2003, 161.)
- Spine Flexion – bending the spine forward to a hunched over position (Exercise Explorer, 2006, exercise analyzer function.)



Lifting From the Ground

Source: Lifting from the ground (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),161

Based on the definitions discussed earlier, the body actions associated with this TRADOC task constitute concentric and isometric muscular contractions (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1.) By examining the TRADOC visual and written description of the task, it becomes clearer. Knee extension, hip-leg extension, spine extension are, by definition, concentric muscle contractions as they represent the positive phase or shortening of muscles (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1) as force is applied to stand up bearing weight that is pictured and described in the manual. These body actions are also related more to muscular strength than muscular endurance since they probably would not be conducted repetitively over a period of time (U.S. Department of the Army, 1998, 3-1.) Once a standing position is gained, spine extension becomes an isometric muscle contraction, exerting force without changing joint angles (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1), to maintain an upright position. Wrist flexion, finger flexion, and thumb flexion, are depicted in the pictures of Soldiers carrying a litter and another Soldier, which represent isometric contractions as per the definition. The TRADOC

manual ensures to warn Soldiers to “keep the hips set and the abdominal muscles tight throughout the lift ”(U.S. Department of the Army, 2003, 161.) Based on this information, spine flexion, which incorporates most of the abdominal muscles and which the Exercise Explorer program credits with maintaining body stabilization, is isometric.

Within each of the muscular actions required to conduct the lifting from the ground, there are numerous individual muscles that are used. Exercise Explorer breaks these body actions down into associated muscles used. The concentric contraction muscles, by body action are shown in Table 16. The muscles associated with the isometric body actions for lifting from the ground are shown in Table 17. This list provides a basis to begin to conduct the comparison against the APFT by body actions, the associated muscles and how they are used.

Table 16. Lift From the Ground Concentric Body Actions Muscle Usage

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Hip-Leg Extension
Abductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Knee Extension
Rectus Femoris
Vastus Intermedius
Vastus Lateralis
Vastus Medialis

Source: Deadlift (E2 Systems Inc., 2006),exercise analysis function

Table 17. Lift From the Ground Isometric Body Actions Muscle Usage

Wrist Flexion
Flexor Carpi Radialis
Flexor Carpi Ulnaris
Palmaris Longus
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Flexor Pollicus Longus

Finger Flexion
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Lumbricals
Palmar Interossei
Abductor Digiti Minimi
Flexor Digiti Minimi Brevis
Opponens Digiti Minimi

Spine Flexion
External Oblique Abdominal
Internal Oblique Abdominal
Longus Colli (inferior oblique)
Longus Colli (superior oblique)
Longus Colli (vertical)
Rectus Abdominis
Scalenus Anterior
Scalenus Posterior

Thumb Flexion
Flexor Pollicis Brevis
Flexor Pollicis Longus
Opponens Pollicis

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Source: Deadlift (E2 Systems Inc., 2006),Body action analysis function

The information gained from the Exercise Explorer is confirmed by several other sources. In an article in *Medicine & Science in Sports & Exercise* specifically addresses and corroborates the major leg muscle groups used to conduct the concentric muscle contractions of the deadlift exercises (Escamilla et al. 2002, 682-684.) In this same article, researchers discuss the deadlift's body stabilization requirements and associated muscle groups, specifically the abdominals. Outside sources could not verify the use of wrist, finger, and thumb flexion requirement in the context of the deadlift. However, an article on rock climbing in *Sports Medicine* discusses the associated muscle groups of the forearms, hands, and fingers, and their importance to the isometric contractions associated with grip strength (Giles, Rhodes, and Taunton, 2006, 535-537.) Based on the Exercise Explorer software and Escamilla's corroboration there is a high degree of confidence that the body actions and muscle groups identified above as being associated with the leg movements are accurate to this task. Based on the software's identification

of the body actions and muscles associated with gripping and the reinforcement by Giles's article even though not specific to the deadlift, these are accepted as part of the actions associated with the deadlift. The body actions associated with stabilization will be used based on Escamilla's article and the stress placed on it in the TRADOC manual description. Table 18 represents the findings in regard to this lifting task and will be utilized in future comparison to the APFT.

Table 18. Final Lifting From the Ground Body Action Analysis

LIFT FROM THE GROUND	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension			X		X
Hip-Leg Extension			X		X
Spine Flexion	X				
Wrist Flexion	X				
Finger Flexion	X				
Thumb Flexion	X				
Spine Extension	X				

The next task identified in the TRADOC PT manual is lifting overhead. The following is the written description from the manual, with associated image (See Figure 5.)

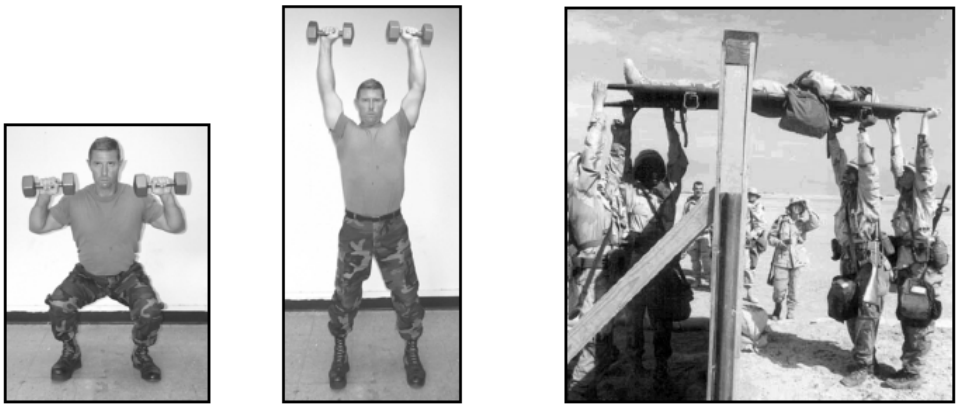
> "Most of the power for pushing an object overhead comes from the legs. To transmit leg strength through the trunk and arms to the object being pushed, set the hips and tighten the abdominal muscles. Hands should be placed shoulder width apart with the upper arms in line with the trunk. Squat slightly then forcefully straighten the legs in a coordinated effort with the actions of the arms." (U.S. Department of the Army, 2003, 162.)

These visual and written physical descriptions of the activity were used to determine

associated body actions and associated muscles used to perform the exercise. Again, the Exercise Explorer software does not have this exact physical task in its catalog of exercises so some interpolation was required to identify body actions for the task. In this case, based on the manual's visual and written depictions of the action, information from both the "squat" and "military press" exercises, along with body stabilization motions, were used to identify body actions. The body actions for the squat as described and defined by Exercise Explorer are similar to the deadlift: knee extension, hip-leg extension, and spine extension. The military press requires wrist flexion, finger flexion, and thumb flexion, which were also addressed previously with the deadlift. The military press further uses the following actions reviewed below:

- Elbow Extension – straightening the elbow from a flexed position (Exercise Explorer, 2006, exercise analyzer function.)
- Arm Flexion – taking the arms upward in front, from the sides to overhead (Exercise Explorer, 2006, exercise analyzer function.)
- Arm Abduction – taking the arms away from the body sideways (Exercise Explorer, 2006, exercise analyzer function.)
- Scapula Elevation – moving the shoulder blades upward as when raising the shoulders (Exercise Explorer, 2006, exercise analyzer function.)

The description of spine flexion will also be used again in order to address the abdominal groups associated with it. This is due, once again, to the TRADOC manual's specific direction to tighten the abdominal muscles (U.S. Department of the Army, 2003, 162.)



Lifting Overhead

Source: Lifting overhead (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),162

Based on the definitions identified previously from Faulkner and FM 21-20, some of these body actions will constitute concentric and isometric muscular contractions. The TRADOC visual and written description of the task clarifies the reasoning. As with the "lifting from the ground" task, knee extension, hip-leg extension, spine extension are concentric muscle contractions, as they represent the positive phase or shortening of muscles (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1) as force is applied to stand up bearing weight as is pictured and described in the manual. Once again, these body actions are related more to muscular strength rather than muscular endurance, according to the FM 21-20 definitions. Once a standing position is gained, spine extension becomes an isometric muscle contraction to maintain an upright position. Wrist flexion, finger flexion, and thumb flexion, are shown in the pictures as Soldiers holding a litter and another Soldier holding weights, which represent isometric contractions as per the definition. The TRADOC manual takes care to warn Soldiers to "set the hips and tighten the abdominal muscles." Based on this information, spine

flexion, which incorporates most of the abdominal muscles and which the Exercise Explorer program credits with maintaining body stabilization, is isometric.

Within each of the muscular actions required to conduct the lifting overhead, there are numerous individual muscles that are used. Exercise Explorer breaks these body actions down into these associated muscles. The concentric contraction muscles for the squat, by body action are shown in Table 19. The concentrically contracting muscles associated with the military press portion of the task are represented in Table 20. The body actions associated with isometric contractions of the military press are shown in Table 21. This list establishes a basis for comparison against the APFT by body actions and associated muscle usage.

Table 19. Muscles of Squat Concentric Contraction Body Actions

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Hip-Leg Extension
Abductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Knee Extension
Rectus Femoris
Vastus Intermedius
Vastus Lateralis
Vastus Medialis

Source: Squat (E2 Systems Inc., 2006), Exercise analysis function

Table 20. Muscles of Military Press Concentric Contraction Body Actions

Arm Flexion
Biceps Brachii
Coracobrachialis
Deltoid Anterior
Pectoralis Major

Scapula Elevation
Levator Scapulae
Rhomboid Major
Rhomboid Minor
Trapezius

Elbow Extension
Anconeus
Extensor Carpi Radialis Brevis
Extensor Carpi Radialis Longus
Extensor Carpi Ulnaris
Extensor digiti Minimi
Extensor Digitorum
Triceps Brachii

Arm Abduction
Deltoid Anterior
Deltoid Middle
Deltoid Posterior
Supraspinatus
Infraspinatus

Source: Squat (E2 Systems Inc., 2006), Exercise analysis function

:

Table 21. Muscles of Military Press Isometric Contraction Body Actions

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Wrist Flexion
Flexor Carpi Radialis
Flexor Carpi Ulnaris
Palmaris Longus
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Flexor Pollicus Longus

Finger Flexion
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Lumbricals
Palmar Interossei
Abductor Digiti Minimi
Flexor Digiti Minimi Brevis
Opponens Digiti Minimi

Thumb Flexion
Flexor Pollicis Brevis
Flexor Pollicis Longus
Opponens Pollicis

Spine Flexion
External Oblique Abdominal
Internal Oblique Abdominal
Longus Colli (inferior oblique)
Longus Colli (superior oblique)
Longus Colli (vertical)
Rectus Abdominis
Scalenus Anterior
Scalenus Posterior

Source: Squat (E2 Systems Inc., 2006), Body action analysis function

The muscle usage and body action information gathered from Exercise Explorer Software has been verified through other sources. An article in *Medicine & Science in Sports & Exercise* specifically addresses and corroborates the major leg muscle groups used to conduct the concentric muscle contractions of the squat exercises (Escamilla et al.

2002, 687.) Researchers addresse the body stabilization requirement to conduct the squat exercise for an article in *Ergonomics* (Duplessis et al. 1998, 795-797.) Documentation which addressed wrist, finger, and thumb flexion in the context of the squat was not available. However, in an article on rock climbing in *Sports Medicine* discusses activation of the associated muscle groups of the forearms, hands, and fingers (Giles, Rhodes, and Taunton, 2006, 535-537). The article further classifies grip strength as a measure of isometric contractions. This grip strength has to be taken into account as necessary based on the TRADOC manual's graphic representation of the task. An article in *Medicine & Science in Sports & Exercise,* corroborates the use of muscles associated with arm flexion, arm abduction, and scapula elevation, used to conduct the military press (Horrigan et al. 1999, 1364.) Based on the Exercise Explorer software and these multiple independent research, the body actions and muscle groups identified as being associated with the leg movements, overhead lifting movements, stabilization movements, and gripping are legitimate for this TRADOC task. The following chart represents the basis for this task as it will be compared to the APFT later in this chapter (See Table 22.)

Table 22. Final Analysis of Lifting Overhead Body Actions

LIFT OVERHEAD	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension			X		X
Hip-Leg Extension			X		X
Spine Extension	X				
Spine Flexion	X				
Wrist Flexion	X				
Finger Flexion	X				
Thumb Flexion	X				
Arm Flexion			X		X
Arm Abduction			X		X
Scapula Elevation			X		X

The third task identified in the TRADOC PT manual is pushing. The following is the written description, with associated image (See Figure 6.)

> "Push with the hands in front of the shoulders and the upper arms close to the body. This technique creates a mechanical advantage that is lost the farther the hands and arms are from this position. Because this method is the most functional, the calisthenic drills use this technique" (U.S. Department of the Army, 2003, 162.)

This visual and written description of the physical task was used to determine associated body actions which can help to identify the muscles used to perform the exercise. The Exercise Explorer software does not have this exact physical task in its catalog of exercises and so some interpolation was required to accurately identify the body actions involved in the task. In this case, because it is specifically pictured and described, the pushup was used to formulate part of the breakdown of this activity. The other portion came from what the Exercise Explorer software termed as driving forward such as from a three point football stance and was chosen based on the picture of Soldiers pushing heavy objects, using their legs as well as upper body. The pushup, described in detail in section one as part of the APFT, will not be covered in depth again in this section. The body actions for the pushup are the same as those used to describe it in the APFT analysis and will be used throughout the rest of the thesis. The body actions associated with the "driving forward" motion are ankle plantar flexion, hip-leg extension, and knee extension. All three of these motions have been defined previously in section one of this chapter.

Pushing

Source: Lifting overhead (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),162

According to Faulkner's definitions and those in FM 21-20 these "driving forward" body actions are associated with concentric muscle contractions, as they are the positive phase of the movement. The TRADOC visual and written descriptions of the task seem only to address the concentric phase and not the eccentric phase. If it did address the concentric and eccentric, that may hint at repetition which is associated with an endurance activity rather than a strength activity, but this is not indicated in the TRADOC manual. Therefore, these "drive forward" body actions are more related to muscular strength rather than muscular endurance, according to the task descriptions and FM 21-20 definitions. However, the pushup alone could still be associated with endurance as it was earlier.

As previously stated, the body actions and muscles used for the pushup were developed in the APFT analysis in section one, thus will not be explored further here. That analysis will continue to be used throughout the thesis where the action of the pushup is called for. Exercise Explorer was used to break down the body actions and

muscles used to conduct the driving forward action. The concentric contraction body actions and muscles used for this activity are available in Table 23. This list provides the basis to conduct the comparison of this task against the APFT by individual muscle and by the associated use and body actions.

Table 23. Muscles of Driving Forward Concentric Contraction Body Actions

Knee Extension
Rectus Femoris
Vastus Intermedius
Vastus Lateralis
Vastus Medialis

Hip-Leg Extension
Abductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Ankle Plantar Flexion
Flexor Digitorum Longus
Flexor Hallucis Longus
Gastrocnemius
Peroneus Brevis
Peroneus Longus
Plantaris
Soleus
Tibialis Posterior

Source: Driving Forward (E2 Systems Inc., 2006), Body action analysis function

Only one journal article was located to lend credence to the Exercise Explorer data for this driving forward action. In an article in the *NZ Journal of Sports Medicine,* the sports injuries suffered by American football players are examined. The article corroborates the assertion that the major leg muscle groups, hamstring, quadriceps, and calf muscles, are used to conduct this loaded push-off action (Orchard, 2002, 92.) These muscle groups represent elements of each of the body actions introduced by Exercise Explorer. Therefore, with a fairly high degree of confidence, it may be stated that the body actions and muscle groups described here are legitimate elements of this TRADOC task (See Table 24.) This chart represents this task as it is interpreted within the context

of the TRADOC manual description. It is a combination of elements of the pushup analysis along with the analysis of the driving forward motion.

Table 24. Final Analysis of Pushing Body Actions

PUSH	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension			X		X
Ankle Plantar Flexion			X		X
Hip-Leg Extension			X		X
Arm Flexion			X		X
Arm Horizontal Adduction			X		X
Elbow Extension			X		X
Spine Extension	X				
Scapula Abduction			X		X

The next task identified in the TRADOC PT manual is pulling or climbing. The following is an excerpt of the written description, with associated image (See Figure 7.)

> "When pulling an object that is on the ground or horizontal to it, Soldiers must assume the power position first. Set the shoulder girdle by pulling the shoulders slightly to the rear. This is also important when pulling the body upward from an overhead grasp. Climbing will often require the legs to power the accent…This will often demand significant strength from the trunk and pelvic muscles." (U.S. Department of the Army, 2003, 163.)

This visual and written description of the activity was used to determine associated body actions which can then help facilitation of identification of the muscles used to perform the exercise. Because the Exercise Explorer software does not carry this exact physical task in its catalog of exercises interpolation was required to identify body actions for the task. In this case, based on the manual's written and pictured description, the general

body actions required to grip, pull the body upwards, and use the legs to push up were used for analysis. Specifically, the pullup for the pulling-the-body-upwards and grip portion and the squat for utilizing-the-legs-to-drive-the-body-up were used. Because there was no specific description or pictorial depiction of pulling an object on the ground or horizontal to the ground, this aspect of the task was not used.

Pulling or Climbing
Source: Lifting overhead (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),163

According to the Exercise Explorer software, the pullup exercise requires arm extension, elbow flexion, head flexion, hip-leg extension, wrist flexion, finger flexion, and thumb flexion, which have all been previously defined and so will not be done again here. However, an additional body action that has not been defined up to this point which is identified and defined by the Exercise Explorer is:

- Scapula Depression – moving the shoulder blades downward as when lowering the shoulders (Exercise Explorer, 2006, exercise analyzer function.)

The body actions and associated muscles for the execution of the squat have already been discussed and will be used for analysis as previously discussed in this

chapter. Spine flexion, which the Exercise Explorer software associates with trunk and abdominal musculature, will also be used. This is due to the TRADOC manual's specificity in regards to trunk and pelvic muscle strength required for this task.

The arm extension, elbow flexion, and scapula depression elements of the pullup exercise are, by the same definitions, eccentric (Faulkner, 2003, 455 and U.S, Department of the Army, 1998, 3-1) and strength (U.S. Department of the Army, 1998, 3-1) focused when viewed in relation to the combat-type tasks pictured in the TRADOC manual. Wrist flexion, finger flexion, and thumb flexion, are shown in the pictures as gripping, as Soldiers are shown holding on to pullup bars, ropes, and window ledges, all of which represent isometric contractions as per the definition (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1). In the squat portion of the task, knee extension, hip-leg extension, spine extension are, by definition, concentric muscle contractions as they represent the positive phase or shortening of muscles as force is applied (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1) to push up as pictured and described in the manual. These body actions are strength rather than endurance, according to the FM 21-20 definitions, because they would more likely be single load or low repetition as opposed to high repetition for a period of time. The TRADOC manual specifically states that significant strength may be required of the trunk and pelvic muscles. Spine flexion, which incorporates most of the abdominal muscles and which the Exercise Explorer program credits with maintaining body stabilization as an isometric contraction, will be used.

Within each of the actions required to conduct the pulling, there are numerous individual muscles that are used. Exercise Explorer breaks these body actions down into

their associated muscles. Based on the Faulkner and FM 21-20 definitions, all of the body actions of this task can be characterized as eccentric, concentric, or isometric. The body actions which are concentric contractions for the pullup are located in Table 25. The isometric body actions and the associated muscles used to conduct the pullup are in Table 26. The body actions and muscles used for the squat, which were identified earlier in the analysis of the "lifting from the ground" and "lifting overhead" tasks, will be used for the remainder of this chapter. The muscles associated with spine flexion, identified in the same "lifting" tasks, will stay constant through the rest of the chapter as well. This information and that in the list above provide a basis to compare this task against the APFT, not only by individual muscle, but also by the associated use and body actions.

Table 25. Muscles of Pullup Concentric Contraction Body Actions

Scapula Depression
Pectoralis Minor
Subclavius
Trapevius
Serratus Anterior

Arm Extension
Deltoid Posterior
Latissimus Dorsi
Subscapularis
Teres Major
Teres Minor
Triceps Brachii

Elbow Flexion
Biceps Brachii
Brachialis
Brachiordialis
Flexor Carpi Radialis
Flexor Carpi Ulnaris
Flexor Digitorum Superficialis
Palmaris Longus
Pronator Teres
Supinator

Source: Pullup (E2 Systems Inc., 2006), Exercise analysis function

Table 26. Muscles of Pullup Isometric Contraction Body Actions

Wrist Flexion
Flexor Carpi Radials
Flexor Carpi Ulnaris
Palmaris Longus
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Flexor Pollicus Longus

Finger Flexion
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Lumbricals
Palmar Interossei
Abductor Digiti Minimi
Flexor Digiti Minimi Brevis
Opponens Digiti Minimi

Thumb Flexion
Flexor Pollicis Brevis
Flexor Pollicis Longus
Opponens Pollicis

Hip-Leg Extension
Abductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Head Flexion
Longus Capitus
Rectus Capitus Anterior
Sternocleidomastoid

Source: Pullup (E2 Systems Inc., 2006), Exercise analysis function

As discussed earlier, an article in *Medicine & Science in Sports & Exercise* specifically addresses and corroborates the major leg muscle groups used to conduct the concentric muscle contractions of the squat exercises (Escamilla et al. 2002, 687.) The associated muscle groups of the forearms, hands, and fingers, and their importance to the isometric contractions associated with grip strength (Giles, Rhodes, and Taunton, 2006, 535-537), which based on the TRADOC manual's graphic representation of the task, has to be incorporated as part of the task of pulling. In an article in *Medicine & Science in Sports & Exercise*, Baurmeister corroborate the use of the pectoralis, deltoid, trapezius, and bicep groups which are associated with arm extension, elbow flexion, and scapula depression which are used to conduct the pullup (Baurmeister, 1997, 573.) Based on the specificity of the task description in the TRADOC manual there is a high level of confidence that the pullup, squat, and spine (trunk) flexion actions described in the Exercise Explorer Software and elsewhere meet the intent of this manual. Therefore based on this intent for the task, there is a high degree of confidence that the body actions

and muscle groups associated with the squat and pullup, as analyzed by the software in corroboration with independent research, are legitimate for this TRADOC task. The following chart represents the analysis of the pull task (See Table 27.) This chart encompasses the squat, pullup, and body stabilization mentioned in the TRADOC manual. It will be used in future comparison with the APFT.

Table 27. Final Pulling or Climbing Body Action Analysis

PULL	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension			X		X
Hip-Leg Extension			X		X
Spine Extension	X				
Spine Flexion	X				
Wrist Flexion	X				
Finger Flexion	X				
Thumb Flexion	X				
Arm Extension			X		X
Elbow Flexion			X		X
Scapula Depression			X		X
Spine Flexion	X				

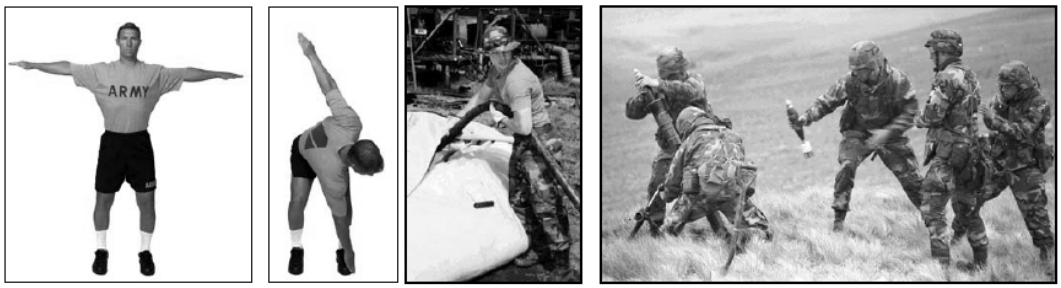
The fifth combat task identified in the TRADOC PT Manual is "Rotation." The written explanation of this task is:

> "Prepare the body's trunk and pelvis to control rotation. Coiling (rotating) the body then quickly uncoiling is the primary source of power for many soldier and athletic tasks such as throwing a punch, heaving an object onto a platform, or kicking a ball. Each of these activities produces a torque on the spine and other joints that may cause injury if the forces are uncontrolled. Control comes from setting the hips, tightening the abdominals, and allowing the hips and knees to bend so as to absorb some of the stress of the rotation." (U.S. Department of the Army, 2003,163.)

Figure 8 is the visual representations offered by the manual to help explain the task. These two descriptions from the manual are the basis by which the task will be analyzed. The following body actions will be used to do this:

- Spine Rotation – rotating the spine to the right or left (Exercise Explorer, 2006, exercise analyzer function), based on the overarching written description and all four pictures.
- Spine Flexion – bending the spine forward to a hunched over position (Exercise Explorer, 2006, exercise analyzer function), based on the "tightening the abdominals" portion of the description and two of the four pictures representing Soldiers bending at the waist.

Based on the FM 21-20 definitions, these actions could be related to either endurance or strength. The written explanation above, together with the pictures points to actions that could be a single effort, "heaving an object onto a platform (U.S. Department of the Army, 2003, 163.)" They may be applied to situations of conducting repeated contractions, such as firing multiple mortar rounds. Also, based on Faulkner's and FM 21-20 definitions, both of these actions are associated with eccentric and concentric muscular contractions.



Rotation

Source: Rotation (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003), 163

Exercise Explorer software identifies the muscle groups associated with these endurance and strength-based, eccentric and concentric body motions as represented in Table 28. Two articles in *Medicine &Science in Sports & Exercise* indicate the stresses placed on the trunk, especially the abdominal group during the spine flexion body action, usually associated with abdominal exercises such as the sit-up (Ricci, Marchetti, and Figura, 1981, 58 and Juker et al. 1998, 305-306). In *Physical Therapy*, researchers specifically measure the percentage of contraction for the upper rectus abdominis, lower rectus abdominis, external obliques, internal obliques, latissimus dorsi, lumbar paraspinals, and rectus femoris during performance of different abdominal exercises associated with spine flexion, providing corroboration that they are used for these actions (Escamilla et al. 2006, 664.) Articles in *Spine Journal* and *Journal of Orthopaedic Research* agree that rectus abdominis, external obliques, internal obliques, latissimus dorsi, and the multifidus are extremely important to spine rotation (Kumar, Narayan, and Zedka 1996, 1500-1501.) Specifically, rotation can be an isometric muscle contraction (Ng et al. 2002, 112-113.)

Based on the Exercise Explorer software and these substantiating sources the following body actions in Table 29 will be used to compare this task with the APFT. Spine flexion and its muscles will be considered eccentric and concentric and will be associated with endurance and strength. Spine rotation will be the same with the addition of the isometric contraction.

Table 28. Muscles of Rotation Body Actions

Spine Flexion
External Oblique Abdominal
Internal Oblique Abdominal
Longus Colli (inferior oblique)
Longus Colli (superior oblique)
Longus Colli (vertical)
Rectus Abdominis
Scalenus Anterior
Scalenus Posterior

Spine Rotation
External Oblique Abdominal
Internal Oblique Abdominal
Multifidus
Rotatores
Semispinalis Cervicis
Semispinalis Thoracis
Scalenus Medius
Scalenus Posterior

Source: Pullup (E2 Systems Inc., 2006), Exercise analysis function

Table 29. Final Rotation Body Action Analysis

ROTATION	Isometric	Eccentric	Concentric	Endurance	Strength
Spine Flexion		X	X	X	X
Spine Rotation	X	X	X	X	X

The sixth task identified in the TRADOC PT Manual is "Jumping and Landing." The written description of this task in the manual is:

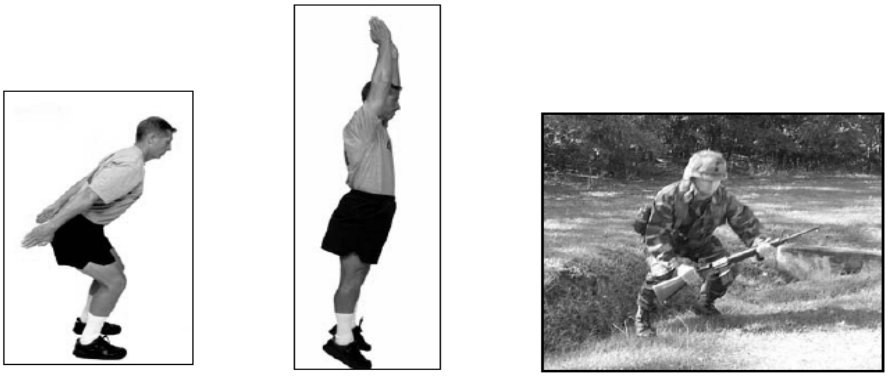
> "Land softly with alignment of the shoulders, knees, and balls of the feet.
> Land first on the balls of the feet with the heels touching down last.
> Bending of the hips and knees allows the legs to serve as coils that absorb

> the impact of the landing. The trunk should be straight but leaning forward so that, when viewed from the side, the shoulders, knees, and balls of the feet are aligned." (U.S. Department of the Army, 2003, 164)

The pictures from the manual offer further explanation (See Figure 9.) These two descriptions from the manual are the basis for the body actions selected for analysis of the performance of this task. Since this specific task is not portrayed in the Exercise Explorer program, some interpolation was used to arrive at the base set of body actions to begin said analysis. For the take-off portion of the task the following body actions, as defined by the Exercise Explorer, were used based on their relevance to the pictures above:

- Ankle Plantar Flexion – taking the toes away from the shin (Exercise Explorer, 2006, body action function) (visually depicted as the act of bending the ankle at the joint.)
- Arm Flexion – taking the arms upward in front, from the sides to overhead (Exercise Explorer, 2006, body action function.)
- Hip-Leg Extension – moving the leg backward from being in front (Exercise Explorer, 2006, body action function.)
- Knee Extension – straightening the leg at the knee (Exercise Explorer, 2006, body action function.)
- Spine Extension – straightening the spine from a hunched over position (Exercise Explorer, 2006, body action function.)
- The body actions associated with the land portion of the exercise were derived from the pictures as well. These actions are:

- Ankle Dorsal Flexion – bringing the toes toward the shin (Exercise Explorer, 2006, body action function) (visually depicted in Exercise Explorer as the act of bending the ankle at the joint.)
- Hip-leg Flexion – moving the leg forward to the front (Exercise Explorer, 2006, body action function) (visually depicted in Exercise Explorer as bending at the waist.)
- Knee Flexion – bending the leg at the knee (Exercise Explorer, 2006, body action function.)
- Spine Flexion – bending the spine forward to a hunched over position (Exercise Explorer, 2006, body action function.)



Jumping and Landing

Source: Rotation (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),164

Referring to FM 21-20 definitions, these actions could be related to either endurance or strength depending on whether or not the action is conducted multiple times or if it is conducted as one maximum effort event. Since it could fall into either category

by definition, it will be considered both. The body actions associated with the take-off portion of the task are most appropriately considered concentric muscle contractions (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1). The actions associated with the land portion of the task are eccentric in accordance with these same definitions (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1.)

Exercise Explorer software identifies the following muscles shown in Table 30 as being associated with these concentric body motions. The software also identifies the muscles in Table 31 as associated with these eccentric contraction body motions. An article in *The Journal of Experimental Biology*, investigates the muscles associated with the actions required to conduct the long jump. The specific muscles that it identified are the gastrocnemius, soleus, rectus femoris, vastus lateralis, vastus intermedius, vastus medialis, semimembranosus, semitendinosus, biceps femoris, gluteus maximus, adductor magnus, adductor brevis, and the adductor longus (Thorpe et al. 1998, 64.) One or more of each of these muscles is associated with one or more of the following body actions; ankle plantar flexion, knee flexion, hip-leg flexion, knee extension, and hip-leg extension. In an article in the *Journal of Biomechanics*, the long jump is broken down into its mathematical components as researchers discover how a person jumps further based on several factors. In the article the authors refer several times to knee flexion and extension as key actions within the long jump (Seyfarth, 1999, 1261.)

Based on these two articles and the Exercise Explorer model, Table 32 depicts the body actions and muscle usage for this task as compared to the APFT. Because no corroboration could be located to support them, the arm motions associated with the jump

will not be used. Since the TRADOC manual does not insist, as it does elsewhere, that it is key, the body stabilization movements of spine flexion and extension will not be used.

Table 30. Muscles of Jumping Concentric Contraction Body Actions

Ankle Plantar Flexion
Flexor Digitorum Longus
Flexor Hallucis Longus
Gastrocnemius
Peroneus Brevis
Peroneus Longus
Plantaris
Soleus
Tibialis Posterior

Arm Flexion
Biceps Brachii
Coracobrachialis
Deltoid Anterior
Pectoralis Major

Hip-Leg Extension
Adductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Knee Extension
Rectus Femoris
Vastus Intermedius
Vastus Lateralis
Vastus Medialis

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Source: Pullup (E2 Systems Inc., 2006), Body action analysis function

Table 31. Muscles of Jumping Eccentric Contraction Body Actions

Ankle Dorsal Flexion
Extensor Digitorum Longus
Extensor Hallucis Longus
Peroneus Tertius
Tibialis Anterior

Knee Flexion
Biceps Femoris
Gastrocnemius
Gracilis
Plantaris
Popliteus
Sartorius
Semimembranosus
Semitendinosus

Hip-Leg Flexion
Adductor Brevis
Adductor Longus
Adductor Magnus
Gluteus Medius
Gluteus Minimus
Gracilis
Iliacus
Pectineus
Psoas Major
Psoas Minor
Rectus Femoris
Sartorius
Tensor Fascia Latae

Spine flexion
External Oblique Abdominal
Internal Oblique Abdominal
Longus Colli (inferior oblique)
Longus Colli (superior oblique)
Longus Colli (vertical)
Rectus Abdominis
Scalenus Anterior
Scalenus Posterior

Source: Pullup (E2 Systems Inc., 2006), Body action analysis function

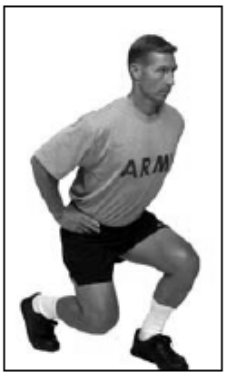
Table 32. Body Actions of Jumping and Landing Final Analysis

JUMP AND LAND	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion			X	X	X
Knee Flexion		X		X	X
Hip-Leg Flexion		X		X	X
Knee Extension			X	X	X
Hip-Leg Extension			X	X	X

The seventh task identified in the TRADOC PT Manual is "Lunging." The written description of this task in the manual is:

> "Maintain the knee of the forward leg in vertical alignment with the ball of the foot. Do not allow the knee to go beyond the toes nor to the right or left of the foot. Lunging is a component of many soldier tasks. The picture below, demonstrates Soldiers' performing a proper lunge as they begin a sprint for cover. Calisthenic and dumbbell exercises that involve lunging prepare Soldiers for functional tasks such as this." (U.S. Department of the Army, 2003, 164)

The graphic representation is located in Figure 10. The basic lunge exercise, found in the Exercise Explorer library, was used to describe the body motions associated with this task. These body motions are knee extension, hip-leg extension, and ankle plantar flexion, which were discussed in relationship to the "jump and land" task, so will not be defined again here. According to the Exercise Explorer program, the following charts show the muscles used to conduct each of the body actions (See Table 33.)



Lunging

Source: Lunging (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),164

Table 33. Muscles of Lunging Body Actions

Ankle Plantar Flexion
Flexor Digitorum Longus
Flexor Hallucis Longus
Gastrocnemius
Peroneus Brevis
Peroneus Longus
Plantaris
Soleus
Tibialis Posterior

Hip-Leg Extension
Adductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Knee Extension
Rectus Femoris
Vastus Intermedius
Vastus Lateralis
Vastus Medialis

Source: Lunging (E2 Systems Inc., 2006), Exercise analysis function

Based on the FM 21-20 definitions, these actions could be related to either endurance or strength, once again dependent on whether or not the action is conducted multiple times or if it is conducted as one maximum effort event. Since it could fall into either category by definition, it will be considered both for the purposes of comparison to the APFT. Even though, by Faulkner and FM 21-20 definitions, there is an eccentric portion to this exercise, the TRADOC manual only shows the exercise in the positive or concentric phase. Due to this representation by the manual, the body actions and muscles

associated with the lunge will only be considered concentric as it is compared the APFT.

An article in the *European Journal of Applied Physiology*, published results of a test to study activation of the vastus lateralis, vastus medialis, biceps femoris, and semitendinosus during execution of the lunge. Researchers collected electromyographic data that suggested an increase in activation of the vastus lateralis and vastus medialis, which are used in knee extension. It also showed an increase in activation of the biceps femoris which is used in hip-leg extension (Pincivero, 2000, 507-508). Since the TRADOC manual alludes to the lunge being conducted as a sprint start, this too was investigated. In a different article in the *European Journal of Applied Physiology*, researchers conducted electromyographic data on the activation of leg muscles during a sprint start. Their study showed activation of the gastrocnemius, vastus lateralis, biceps femoris, rectus femoris, and gluteus maximus during a sprint start (Mero and Komi, 1990, 77-79.) At least one of each of these muscles is associated with ankle plantar flexion, knee extension, and hip-leg extension. Based on these two articles and the Exercise Explorer model, Table 34 depicts the body actions and muscle usage as this task is compared to the APFT.

Table 34. Final Analysis of Lunging Body Actions

Lunge	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion			X	X	X
Knee Extension			X	X	X
Hip-Leg Extension			X	X	X

The next task identified in the TRADOC Manual is "Marching." An excerpt from the description supplied in the manual is:

> "…Allow the arms to swing naturally… Allow the hips to rotate forward with each stride…Stride naturally, landing on the heel…Foot marching with a load on the back will require some forward lean of the trunk…" (U.S. Department of the Army, 2003, 165)

Figure 11 from the TRADOC Manual shows marching with and without loads. The Exercise Explorer library has the body motions and muscles used for hiking in its library of activities. Since this is a comparable action, hiking will be used as the base set of body actions and muscles as this task is analyzed. According to the Exercise Explorer program, the Table 35 shows the muscles used to conduct each of the body actions. As these body actions were defined earlier in the "run" analysis, they will not be defined again here.

Marching

Source: Marching (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),165

Table 35. Muscles of Hiking Body Actions

Knee Flexion
Biceps Femoris
Gastrocnemius
Gracilis
Plantaris
Popliteus
Sartorius
Semimembranosus
Semitendinosus

Hip-Leg Flexion
Adductor Brevis
Adductor Longus
Adductor Magnus
Gluteus Medius
Gluteus Minimus
Gracilis
Iliacus
Pectineus
Psoas Major
Psoas Minor
Rectus Femoris
Sartorius
Tensor Fascia Latae

Knee Extension
Rectus Femoris
Vastus Intermedius
Vastus Lateralis
Vastus Medialis

Hip-Leg Extension
Adductor Magnus
Biceps Femoris
Gluteus Maximus
Gluteus Medius
Semimembranosus
Semitendinosus

Spine Extension
Iliocostalis Cervicis
Iliocostalis Lumborum
Iliocostalis Thoracis
Interspinalis
Longissimus Capitis
Longissimus Cervicis
Longissimus Dorsi
Multifidus
Quadratus Lumborum
Rotatores
Semispinales Cervicis
Semispinales Thoracis
Spinales Capitis
Spinales Cervicis
Spinales Dorsi

Head Extension
Longissimus Capitis
Obliquuus Capitis Superior
Rectus Capitis Posterior (major)
Rectus Capitis Posterior (minor)
Spinalis Capitis
Splenius Capitis
Splenius Cervicis
Trapezius

Source: Hiking (E2 Systems Inc., 2006), Activity analysis function

Two specific journal articles corroborate the body actions associated with the legs. An article in *Clinics in Sports Medicine* associates hip-leg flexion and knee flexion with walking, running, and sprinting. It also identifies the presence of hip-leg extension and knee extension (Thorardson, 1997, 243.) In an article in *The American Journal of Sports Medicine*, knee and hip-leg flexion and knee and hip-leg extension are identified as components of walking (Mann, 1980, 346). Both articles further identified ankle dorsal flexion and ankle plantar flexion as components of walking, which the Exercise Explorer program did not. The muscles associated with these body actions are shown in Table 36. Neither Mann nor Thordarson referred to body stabilization actions associated with sprinting, running, or walking. No other sources could be located that supported the

use of head extension and spine extension as being components of walking. Therefore, these actions will not be used in the comparison portion of the research.

Table 36. Muscles of Ankle Dorsal and Plantar Flexion Body Actions

Ankle Dorsal Flexion
Extensor Digitorum Longus
Extensor Hallucis Longus
Peroneus Tertius
Tibialis Anterior

Ankle Plantar Flexion
Flexor Digitorum Longus
Flexor Hallucis Longus
Gastrocnemius
Peroneus Brevis
Peroneus Longus
Plantaris
Soleus
Tibialis Posterior

Source: Flexion (E2 Systems Inc., 2006), Body action analysis function

The body actions associated with the leg backward and forward movement are related to endurance because they are repeated contractions against a less than maximum resistance (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1.) The Exercise Explorer software classifies the muscles associated with extension body actions as being eccentric. Faulkner's and FM 21-20's definitions seem to support this, but Thordarson found that muscles could act concentrically and eccentrically at the same time. Based on the information presented in these two articles and the Exercise Explorer model, Table 37 depicts the body actions and muscle usage that will be used to compare this task to the APFT.

Table 37. Final Analysis of Marching Body Actions

MARCH	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion			X	X	
Ankle Dorsal Flexion			X	X	
Knee Flexion			X	X	
Hip-Leg Flexion			X	X	
Knee Extension			X	X	
Hip-Leg Extension			X	X	

The last task in the TRADOC Manual is "Running." An excerpt from the description in the manual is:

> " Changing Direction… Soldiers may be required to quickly change direction while maintaining forward movement or to reverse direction…" (U.S. Department of the Army, 2003, 166)

Figure 12 from the TRADOC Manual helps to clarify the intent of the task. This task will be broken down into two components. The first component is running, just as the task is named. The second component will be the "changing direction" aspect. Because running has already been analyzed in section one of this chapter, it will not be re-analyzed. The following data from the previous analysis will continue to be used to describe running (See Table 38.)

Running

Source: Running (TRADOC Standardized Physical Training Guide, U.S. Department of the Army, 2003),166

Table 38. Final Analysis of Run Body Actions

RUN	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension		X	X	X	
Ankle Plantar Flexion		X	X	X	
Hip-Leg Extension		X	X	X	
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	

The Exercise Explorer software does not have "changing direction" specifically, but it does analyze soccer or rugby field movement, consisting of stopping forward and moving sideways, and, thus it was selected to form the basis for this portion of the task since this action was the closest description. The software identifies ankle dorsal flexion, ankle plantar flexion, head extension, hip-leg extension, knee extension, and spine extension, as body actions required to conduct this movement. It identifies and defines several other actions that have not been previously discussed:

- Ankle Eversion – bringing the bottom of the foot laterally outward (Exercise Explorer, 2006, body action function.)

- Ankle Inversion – bringing the bottom of the foot laterally inward (Exercise Explorer, 2006, body action function.)
- Hip-leg Abduction – Bringing the leg inward from being out sideways (Exercise Explorer, 2006, body action function.)
- Hip-leg adduction – taking the leg outward sideways (Exercise Explorer, 2006, body action function.)

The muscles associated with each of these newly introduced actions are illustrated in Table 39.

Table 39. Muscles of Field Movement Body Actions

Ankle Eversion
Extensor Digitorum Longus
Peroneus Brevis
Peroneus Longus
Peroneus Tertius

Ankle Inversion
Flexor Hallucis Longus
Tibialis Anterior
Tibialis Posterior
Extensor Hallucis Longus
Flexor Digitorum Longus

Hip-Leg Adduction
Adductor Brevis
Adductor Longus
Adductor Magnus
Gracilis
Pectineus
Biceps Femoris (hamstrings)
Gluteus Maximus
Iliacus
Semimembranosus (hamstrings)
Semitendinosus (hamstrings)

Hip-Leg Abduction
Gluteus Medius
Gluteus Minimus
Tensor Fasciae Latae
Sartorius

Source: Field Movement (E2 Systems Inc., 2006), Activity analysis function

In an online article dealing with injuries to the hamstring muscles in soccer, rugby, and football, authors discuss the use of the hamstring muscles and the adductor muscles during field movement (Gambetta and Benton, n.d., 1-5.) Table 39 shows these muscles' association with hip-leg adduction. Although not specifically discussing hip-leg adduction, the conclusion may reasonably be drawn that this is a valid body action associated with this activity. An article in *Gait Posture*, discusses the electromyographic

data observed in players conducting quick change in running directions. The muscles that they specifically measured were the gluteus medius, sartorius, vastus medialis, and gastrocnemius (Rand and Ohtsuyuki, 2000, 175.) These muscles are associated with hip-leg abduction, knee extension, and ankle plantar flexion. This information thus allows for the conclusion that these are valid body motions associated with this field movement. Since no data could be found to corroborate the ankle eversion and inversion motions, these will no longer be used for analysis of the field movement type activity. Table 40 represents the muscular usage for this activity as it will be compared to the APFT later in this chapter.

Table 40. Final Analysis of Running Changing Direction Body Actions

RUN - CHANGING DIRECTION	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension		X	X	X	
Ankle Plantar Flexion		X	X	X	
Hip-Leg Extension		X	X	X	
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	
Hip-Leg Adduction		X	X	X	
Hip-Leg Abduction		X	X	X	

The muscle movements are classified as eccentric and concentric based on the definitions used throughout the chapter (Faulkner, 2003, 455 and U.S. Department of the Army, 1998, 3-1.) They are also used based on Thoradson's article which attributes both types of contractions during running. The movements are considered endurance based (U.S. Department of the Army, 1998, 3-1.)

In conclusion, the following chart shows the muscular usage for tasks identified in the TRADOC manual, which were utilized as a baseline set of combat tasks. Table 41 shows the body motions and associated contraction and for the associated muscles. This chart represents a cumulative picture and will be compared against the similar chart developed for the APFT in the first section of the chapter.

Table 41. Final Analysis of TRADOC Task Muscular Usage

TRADOC TASKS	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension		X	X	X	X
Hip-Leg Extension		X	X	X	X
Spine Flexion	X	X	X	X	X
Wrist Flexion	X				
Finger Flexion	X				
Thumb Flexion	X				
Spine Extension	X				
Arm Flexion			X		X
Arm Abduction			X		X
Scapula Elevation			X		X
Ankle Plantar Flexion		X	X	X	X
Arm Horizontal Adduction			X		X
Elbow Extension			X		X
Scapula Abduction			X		X
Arm Extension			X		X
Elbow Flexion			X		X
Scapula Depression			X		X
Spine Rotation	X	X	X	X	X
Knee Flexion		X	X	X	X
Hip-Leg Flexion		X	X	X	X
Ankle Dorsal Flexion		X	X	X	
Hip-Leg Adduction		X	X	X	
Hip-Leg Abduction		X	X	X	

Section 3

This section will introduce the results of a survey of Intermediate Level Education (ILE) majors which was meant to explore current attitudes toward physical fitness and physical training in preparation for the Current Operating Environment (COE.) An example of the survey is located in Appendix A of the thesis. It was conducted online and was facilitated and approved by the Command and General Staff (CGSC) Quality assurance Office (QAO.) The results of the survey were used to identify six combat tasks that will be analyzed here and compared to the APFT in the next section.

The CGSC QAO delivered the invitation to participate in the survey to almost 600 ILE majors. Of those 600 majors, 353 responded and answered the survey. Of the 353 responses, 349 were used. The four that were not used were from personnel who answered that they were not United States Army (active duty, reserve or national guard.) The survey asked participants what their branch was; Maneuver, Fires, and Effects (MFE), Operational Support (OS), Force Sustainment (FS), Health Services (HS), or Other Special Branches. Participants were also asked if they had been deployed in support of the Global War on Terror (GWOT) to Operation Iraqi Freedom (OIF), Operation Enduring Freedom (OEF), or both, as well as what positions they had held during each deployment. Respondents were then given the opportunity to choose the 6, in their opinion, most important of 22 “combat tasks” and to rank order them from most (number 1) to least (number 6) important. The available task choices were taken from the TRADOC PT manual and opinions of personnel on the Center for Army Lessons Learned (CALL) website and Company Command website as discussed in the literature review.

The first three questions established the population of the respondents. Table 42 is representative of the entire population of respondents. Of the 349 responses, 310 were OIF or OEF veterans, with 203 of those having served as a commander or on a Military Transition Team (MiTT). Of the 203 with command or MiTT experience in theater, 136 were MFE and 67 were other branches. Out of the 203 GWOT veterans only 67 had not served in a command position or on a MiTT. Only 39 respondents had not deployed in support of the GWOT. None of the groups within the entire population had their answers weighted more heavily than others. However it is interesting to note later, how the different groups above chose to weight the combat tasks.

Table 42. Population of Majors used for ILE Survey

	Raw #	%
Overall	349	100
GWOT Vets	310	88.8
CDR / MITT Experience	203	58.2
MFE	136	39
Non-MFE	67	19.2
Staff	107	41.8
Non-GWOT Vets	39	11.2

In order to identify the top 6 tasks from the 22 that were proposed, respondents rank ordered from 1 to 6 (1 being the most important) what they thought were the six most important physical tasks a Soldier must do in order to stay alive, protect his or her comrades, or do his or her job. The results from all 349 respondents were tabulated across the 22 tasks by assigning six points to the number one answer, five points to the number two answer, four points to the number three answer, three points to the number

four answer, two points to the number five answer, and one point to the number six answer. Table 43 shows how this was accomplished.

Table 43. Raw Results from ILE Majors Survey

		1		2		3		4		5		6		7		8		9		10		11	
		raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value
rank	1	192	1152	13	78	46	276	4	24	6	36	2	12	1	6	4	24	2	12	2	12	4	24
	2	63	315	35	175	113	565	6	30	24	120	1	5	5	25	5	25	4	20	5	25	4	20
	3	25	100	50	200	63	252	15	60	35	140	3	12	2	8	26	104	1	4	3	12	18	72
	4	11	33	43	129	35	105	11	33	44	132	4	12	2	6	27	81	5	15	7	21	22	66
	5	17	34	24	48	24	48	30	60	29	58	5	10	3	6	27	54	6	12	20	40	19	38
	6	7	7	21	21	12	12	19	19	33	33	16	16	7	7	21	21	7	7	11	11	16	16
			1641		651		1258		226		519		67		58		309		70		121		236

		12		13		14		15		16		17		18		19		20		21		22	
		raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value	raw	value
rank	1	1	6	52	312	0	0	0	0	2	12	1	6	2	12	1	6	0	0	1	6	13	78
	2	2	10	58	290	2	10	1	5	0	0	2	10	9	45	3	15	0	0	3	15	3	15
	3	14	56	43	172	7	28	0	0	3	12	3	12	20	80	6	24	1	4	5	20	2	8
	4	9	27	48	144	6	18	1	3	6	18	2	6	38	114	7	21	2	6	12	36	1	3
	5	21	42	18	36	12	24	5	10	5	10	2	4	41	82	10	20	6	12	14	28	2	4
	6	22	22	18	18	14	14	5	5	9	9	7	7	29	29	19	19	3	3	30	30	6	6
			163		972		94		23		61		45		362		105		25		135		114

Task number one in the chart above shows 192 under the “raw” column. This means that 192 personnel ranked it as the number one “combat task.” Not only did 192 rank it number one, but 63 ranked it number two, 25 ranked it number three, 11 ranked it number four, 17 ranked it number five, and 7 ranked it number six. The 192 is multiplied by 6 to get the value of 1152, the 63 is multiplied by 5 to get the value of 315, the 25 is multiplied by 4 to get the value of 100 and so on as described earlier. The total “value” for task number one is 1641, which is the sum of the intermediate values. All “values” for each task are assessed in this same manner.

Based on the procedures described in the previous paragraph, the respondent ILE majors chose tasks 1, 2, 3, 5, 13, and 18 as the six most important physical tasks that a

Soldier must be able to perform in combat. The description of these tasks as worded in the survey are:

Descriptors:

1. Move from one covered and concealed position to another
2. Lift a weight from the ground (eg stretcher)
3. Drag a casualty to safety
5. Conduct a fireman's carry
13. Continuous movement under combat load (road march)
18. Climb over a wall

These results were then verified by the CGSC QAO which was responsible for administering the survey. Using the Friedman Test and Kendal's W Test, tasks 1, 2, 3, 5, 13, and 18 were confirmed as the top six, in the same order. These tests also provided further data to lend credit to the survey. Both tests showed an asymptotic significance of .000, which meant that there was a near zero chance that the results of the test were by sheer chance. Kendall's W (a coefficient of concordance) was .396 which showed moderate agreement among those who answered the survey. Based on this information, the results of the survey are deemed statistically significant.

Task number one, "Move from one covered and concealed position to another," will be analyzed based on the description of the "rush" technique, a component of Individual Movement Techniques (IMT) described in Soldier basic task manuals (U.S. Department of the Army, 2007, 3-152.) The elements of this description have already been analyzed earlier in this chapter based on the tasks "lunging" and "running" in the TRADOC Manual. The "lunge" task is described in the TRADOC manual as being a

component of sprinting for cover and is referred to in the SMCT (U.S. Department of the Army, 2007, 3-152.) The "running" task in the TRADOC manual shows an illustration of a Soldier obviously conducting IMT and speaks of running while changing direction, which is a component of moving between covered and concealed positions. The last element that will be used is the pushup as it is used for pushing the body up from the ground from a prone position (U.S. Department of the Army, 2007, 3-152.) Table 44 illustrates the conglomerate of these three tasks. This chart will be used to develop the composite chart showing muscular usage for all of the "combat tasks".

Table 44. Final Analysis for Movement Task from the ILE Survey

Task 1 (Move)	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion		X	X	X	X
Knee Extension		X	X	X	X
Hip-Leg Extension		X	X	X	X
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	
Hip-Leg Adduction		X	X	X	
Hip-Leg Abduction		X	X	X	
Arm Flexion		X	X	X	
Arm Horizontal Adduction		X	X	X	
Elbow Extension		X	X	X	
Spine Extension	X				
Scapula Abduction		X	X	X	

The next task identified in the survey was task number two, "lift a weight from the ground (eg stretcher)." This task, for purposes of analysis, will be equated with the TRADOC task discussed earlier, "lifting from the ground." The chart resulting from the analysis of that TRADOC task will be used to develop the "combat tasks" composite chart.

The third task identified in the survey was number three, “drag a casualty to safety.” This task was not analyzed completely earlier in the context of the APFT or the set of TRADOC tasks. For the purposes of analysis this task will be broken down into two specific portions, “lunging” which would account for the leg motions of pushing off as it is described in the TRADOC manual, and the arm motions required to perform the action. These specific arm motions are:

- Elbow extension – straightening the arm at the elbow (Exercise Explorer, 2006, body action function.)
- Finger Flexion – bending the fingers toward the palm such as to make a fist (Exercise Explorer, 2006, body action function.)
- Thumb Flexion – bending the thumb toward the palm such as to make a fist (Exercise Explorer, 2006, body action function.)

The muscles associated with these three body actions are located in Table 45. The three body actions are associated with isometric muscle contractions as they are all exerting force without changing angles on the joints (Faulkner, 2003, 455) The muscles are also more likely to be associated with strength rather than endurance since they would probably not be conducted multiple times over a given time period but more likely conducted once (U.S. Department of the Army, 1998, 3-1.)

Table 45. Muscles of Drag a Casualty Isometric Contraction Body Actions

Elbow Extension
Anconeus
Extensor Carpi Radialis Brevis
Extensor Carpi Radialis Longus
Extensor Carpi Ulnaris
Extensor digiti Minimi
Extensor Digitorum
Triceps Brachii

Finger Flexion
Flexor Digitorum Profundus
Flexor Digitorum Superficialis
Lumbricals
Palmar Interossei
Abductor Digiti Minimi
Flexor Digiti Minimi Brevis
Opponens Digiti Minimi

Thumb Flexion
Flexor Pollicis Brevis
Flexor Pollicis Longus
Opponens Pollicis

Source: Body Actions (E2 Systems Inc., 2006), Body Action analysis function

In the absence of literature to substantiate this arm portion of "drag a casualty to safety", some interpolation was conducted to provide further substantiation. Finger flexion and thumb flexion are associated with gripping. In the journal *Knee Surgery, Sports Traumatology, Arthroscopy*, authors investigated muscle usage of rock climbers. They specifically measured muscles associated with the finger and thumb flexion actions, showing that the two are related to gripping (Koukoubis et al. 1995, 121.) In another article, authors show that the gripping actions are in fact isometric in nature (Giles, Rhodes, and Taunton, 2006, 535-537.) Elbow extension is associated with multiple extensor muscles and most notably the triceps brachii (Cogley et al. 2005, 630.) Based on these journal articles, and past analysis of "lunging", Table 46 will be used as the basis for the "pull a casualty to safety" task. It will be used to develop the "combat tasks" composite chart of muscular usage.

Table 46. Final Analysis of Pull a Casualty to Safety Body Actions

Task 3 (Pull a casualty)	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion			X	X	X
Knee Extension			X	X	X
Hip-Leg Extension			X	X	X
Elbow Extension	X				X
Finger Flexion	X				X
Thumb Flexion	X				X

The fourth task is "conduct a fireman's carry". Since the TRADOC manual includes a photo of a Soldier conducting a fireman's carry as an example of the "lift from the ground" task identified earlier, these two tasks will be considered the same for the purposes of comparison to the APFT. For that reason, the body actions associated "lift from the ground" TRADOC task will be used to analyze this "combat task" as well.

The fifth task the survey identified is "continuous movement under a combat load (road march.)" The sixth and last task is "climb over a wall". Both of these tasks have been analyzed earlier in this chapter within the TRADOC task analysis. Therefore, both tasks will utilize the sets of body actions already identified, as they are compared to the APFT.

The following chart is a composite of all the body actions associated with all six tasks ILE majors identified through the survey (See Table 47.) These body actions, along with those associated with the TRADOC tasks can now be compared to the similar chart developed for the APFT earlier in this chapter. To provide better clarity, both the TRADOC tasks chart (See Table 48) and the APFT chart (See Table 49) are included below.

Table 47. Final Analysis of Muscle Usage Associated with "Combat Tasks"

Combat Tasks	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion		X	X	X	X
Knee Extension		X	X	X	X
Hip-Leg Extension		X	X	X	X
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	
Hip-Leg Adduction		X	X	X	
Hip-Leg Abduction		X	X	X	
Arm Flexion		X	X	X	
Arm Horizontal Adduction		X	X	X	
Elbow Extension	X	X	X	X	X
Spine Extension	X				
Scapula Abduction		X	X	X	
Spine Flexion	X				
Wrist Flexion	X				
Finger Flexion	X				X
Thumb Flexion	X				X
Hip-Leg Flexion			X	X	
Arm Extension			X		X
Elbow Flexion			X		X
Scapula Depression			X		X

Table 48. Final Analysis of Muscle Usage Associate with TRADOC Tasks

.

TRADOC TASKS	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension		X	X	X	X
Hip-Leg Extension		X	X	X	X
Spine Flexion	X	X	X	X	X
Wrist Flexion	X				
Finger Flexion	X				
Thumb Flexion	X				
Spine Extension	X				
Arm Flexion			X		X
Arm Abduction			X		X
Scapula Elevation			X		X
Ankle Plantar Flexion		X	X	X	X
Arm Horizontal Adduction			X		X
Elbow Extension			X		X
Scapula Abduction			X		X
Arm Extension			X		X
Elbow Flexion			X		X
Scapula Depression			X		X
Spine Rotation	X	X	X	X	X
Knee Flexion		X	X	X	X
Hip-Leg Flexion		X	X	X	X
Ankle Dorsal Flexion		X	X	X	
Hip-Leg Adduction		X	X	X	
Hip-Leg Abduction		X	X	X	

Table 49. Final Analysis of Muscular Usage Associated with APFT Tasks

APFT Exercises	Isometric	Eccentric	Concentric	Endurance	Strength
Arm Flexion		X	X	X	
Arm Horizontal Adduction		X	X	X	
Elbow Extension		X	X	X	
Spine Extension	X				
Scapula Abduction		X	X	X	
Hip-Leg Flexion		X	X	X	
Spine Flexion		X	X	X	
Knee Extension		X	X	X	
Ankle Plantar Flexion		X	X	X	
Hip-Leg Extension		X	X	X	
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	

Table 50. Shortfalls of the APFT When Compared to "Combat Tasks"

Combat Tasks	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion					X
Knee Extension					X
Hip-Leg Extension					X
Hip-Leg Adduction		X	X	X	
Hip-Leg Abduction		X	X	X	
Elbow Extension	X				X
Spine Flexion	X				
Wrist Flexion	X				
Finger Flexion	X				X
Thumb Flexion	X				X
Hip-Leg Flexion			X	X	
Arm Extension			X		X
Elbow Flexion			X		X
Scapula Depression			X		X

By simply comparing the APFT chart with the "Combat Tasks" chart shortfalls are readily identified based on the body motions and how the muscles are used during that motion. Table 50 graphically illustrates the shortfalls of what the APFT tests, compared to what ILE majors would expect of a Soldier in combat. According to the chart, the body motion ankle plantar flexion as a component of strength is required to conduct one or more of the combat tasks and the APFT does not measure it in that manner. Another example is Hip-Leg Adduction which, according to the chart is required as a component of endurance, contracting eccentrically and concentrically, which the APFT does not measure. Further body motions in the chart should be interpreted in a similar manner.

The alternative to the shortfalls chart is one that illustrates what the APFT does measure and is required to conduct the combat tasks. Table 51 shows this data. This chart shows that Ankle Plantar Flexion is measured by the APFT as it contracts

eccentrically and concentrically as a component of endurance, as required by the "combat tasks." The other body actions should be interpreted in a similar fashion.

Table 51. Analysis of What the APFT Does Measure of the "Combat Tasks"

Combat Tasks	Isometric	Eccentric	Concentric	Endurance	Strength
Ankle Plantar Flexion		X	X	X	
Knee Extension		X	X	X	
Hip-Leg Extension		X	X	X	
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	
Arm Flexion		X	X	X	
Arm Horizontal Adduction		X	X	X	
Elbow Extension		X	X	X	
Spine Extension	X				
Scapula Abduction		X	X	X	

Table 52. Shortfalls of the APFT When Compared to TRADOC Tasks

TRADOC Tasks	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension					X
Hip-Leg Extension					X
Spine Flexion	X				
Wrist Flexion	X				
Finger Flexion	X				
Thumb Flexion	X				
Arm Flexion					X
Arm Abduction			X		X
Scapula Elevation			X		X
Ankle Plantar Flexion					X
Arm Horizontal Adduction					X
Elbow Extension					X
Scapula Abduction					X
Arm Extension			X		X
Elbow Flexion			X		X
Scapula Depression			X		X
Spine Rotation	X				X
Knee Flexion					X
Hip-Leg Flexion					X
Hip-Leg Adduction		X	X	X	
Hip-Leg Abduction		X	X	X	

The TRADOC tasks, which were used due to the absence of better official guidance, were also compared to the APFT. Table 52 illustrates the shortfalls associated with the TRADOC tasks. As with the combat tasks, this chart should be interpreted as such: the Knee Extension body motion is associated with strength in one or more of the TRADOC tasks, but is not tested in this manner in the APFT. Another example is Hip-Leg Adduction, which is required to contract eccentrically and concentrically as a component of endurance in order to conduct one or more of the TRADOC tasks. The rest of the chart should be interpreted in the same manner.

Since the shortfalls are identified, it is only appropriate to illustrate what body actions are measured by the APFT. Table 53 illustrates these body actions. As with earlier illustrations, the knee extension, for example, is measured as a component of endurance and contraction of associated muscles both eccentrically and concentrically. The other body actions are interpreted the same.

Table 53. Analysis of What the APFT Does Measure of the TRADOC Tasks

TRADOC Tasks	Isometric	Eccentric	Concentric	Endurance	Strength
Knee Extension		X	X	X	
Hip-Leg Extension		X	X	X	
Spine Flexion		X	X	X	
Spine Extension	X				
Arm Flexion			X		
Ankle Plantar Flexion		X	X	X	
Arm Horizontal Adduction			X		
Elbow Extension			X		
Scapula Abduction			X		
Spine Rotation		X	X	X	
Knee Flexion		X	X	X	
Hip-Leg Flexion		X	X	X	
Ankle Dorsal Flexion		X	X	X	

In conclusion, this chapter has explored the basic body motions associated with the elements of the APFT, the TRADOC manual tasks, and the tasks resulting from the survey of ILE majors. All of these body motions were analyzed based on whether they were isometric, eccentric, or concentric muscular contractions. They were also characterized as being associated with endurance and or strength. Each of these sets of body actions was used to develop a visual representation of what was required to conduct the APFT, the TRADOC tasks, and the "combat tasks" from the survey. Once compared, it is clear that, on a muscular level, the APFT does not measure all of the components required to conduct either the set of TRADOC tasks or the set of combat tasks from the survey. Specifically, the elements of the APFT seem to be focused almost exclusively on muscular endurance, whereas the TRADOC tasks and "combat tasks" have a number of strength based tasks and utilize more isometric contraction. Also, as discussed earlier, although marching or walking, running, and sprinting use the same muscles, there are fundamental differences in these activities. Specific examples are the differences in center of balance for each, percentage of muscular usage, and joint range of motion (Thorardson, 1997, 242-243), which leads to the likelihood that each activity may need to be trained specifically. The next chapter will discuss recommendations to make up for these shortfalls.

CHAPTER 5

CONCLUSION

The current Army Physical Fitness Test (APFT) is a measure of general well-being, not a test of combat readiness. Professional combat leaders have expressed a feeling of the need for a way to test for combat readiness and a general lack of satisfaction with the APFT. There is evidence of this not only in the Army but in the Marines Corps. Throughout the Army, there is evidence that units are developing supplementary programs and tests of physical fitness. These supplementary tests and programs are not Army-wide and therefore lack oversight and recognition. The Marine Corps however, is currently working toward adopting a supplementary Combat Fitness Test (CFT), in addition to their current fitness test which would be used across the service. This is the direction that the Army needs to take.

This thesis has explored the APFT on a muscular level. It has done the same with a set of tasks in the Training and Doctrine Command (TRADOC) Physical Training (PT) Manual and a set of tasks identified by U.S. Army majors attending Intermediate Level Education (ILE) Class 08-01. Five of the six tasks identified by these majors are also five of the eight TRADOC tasks. The Army must listen to its young field grade and company grade leaders. These personnel are closest to the fight, and therefore have a very good understanding of what training is required to keep Soldiers alive in combat. Their insight, from all branches of the Army, could be invaluable in developing a new program for testing physical readiness for combat.

This analysis has identified a set of muscular shortcomings that the APFT does not test, which would be needed to conduct either the set of TRADOC tasks or the combat tasks from the survey. In general, the APFT specifically measures muscular endurance where the TRADOC tasks and combat tasks require muscular strength. Also, there are fundamental differences in muscular usage in walking, running, and sprinting. Granted, this muscular strength and endurance is only one aspect of fitness. Some other elements not analyzed were balance, flexibility, and cardiovascular fitness. With further study, these other elements of fitness could be properly studied.

In order to make up the shortfalls, at least at the muscular level, the results of this study could be used to identify further exercises that measure muscular strength could be added to the current APFT. This could be done by a process of reverse engineering, using the shortfall body actions, selecting and testing exercises utilizing these body actions, and then picking those that are utilized in the way that is identified in chapter four. This could possibly result in more exercises being added to the current APFT. The consequences of this longer test could be its ease of conduct at the unit level. However, this could be mitigated if exercises requiring no outside resources (weights, apparatus, etc.) were used.

An alternative course of action would be to adopt a supplemental test, such as the Marines have done. This Marine test will consist of a grenade throw, variations of maneuver under fire, casualty carry (specifically the fireman's carry), casualty drag, and ammunition re-supply (sprinting while carrying two weighted ammunition cans). Although not analyzed in detail, on the surface this test would specifically emulate four of the six tasks identified in the survey; move from one covered and concealed position to

another, lift from the ground, conduct a fireman's carry, and drag a casualty to safety. Not only may it meet specific muscular testing shortfalls of the APFT, but the fact that it specifically mimics these combat tasks, it may test multiple aspects of fitness such as balance and flexibility. The drawback to this test would be its reliance on training aids. It could not be conducted just anywhere, as it requires a specifically laid out and measured field, cones and other markers, casualties, and other aids. However, this may be a small price to pay for focusing Soldiers to meet the demands of combat rather than a simple APFT.

In conclusion, the APFT may be meant to measure general fitness, but the Army requires more than general fitness to prepare Soldiers for the rigors of combat. The Army as a whole, and Soldiers specifically are being called on to fight. It does not matter if a Soldier is an infantryman or a military intelligence analyst, he or she has to be prepared to fight to stay alive or preserve the life of another. In order to do that, Soldiers have to be physically ready for the rigors of combat. The APFT admittedly does not test that readiness. It is about time that there was one standard across the Army. This study presents the muscular shortfalls of the APFT and a recommended way ahead to develop one standard across the Army.

APPENDIX A

INTERMEDIATE LEVEL EDUCATION (ILE) CLASS 08-01 SURVEY

The following survey is an information gathering tool for a MMAS thesis concerning the applicability of the Army Physical Fitness Test in training Soldiers for the Contemporary Operating Environment. If you are not US Army, Army Reserve, or Army National Guard, please disregard.

By answering these questions you are acknowledging that the information you provide may be used in conducting this study. Answers are confidential and your name will not be used.

The *Background* information is meant to establish a demographic for the population. Provide your branch with the appropriate two or three letter abbreviation. For each GWOT tour you have, fill in OIF or OEF. Under position, enter the position you held during that deployment; Staff, Commander, or transition team. If you served in two or more positions on the same tour, enter both or all three.

Under the *Combat Task* section rank 1 to 6, the top six most important tasks that, in your experience, a Soldier should be able to do in order to complete the mission, protect other Soldiers, etc. (1 being the most important) Rank only six tasks. If there is a task that you think should be on here but is not, type it in the last box and rank it.

Branch			
MFE	OS	FS	OS

GWOT Deployments			
OIF	OEF	OIF and OEF	Neither

Position held during your deployment (choose all that apply)		
Staff	Commander	Transition Team

Task	Rank 1-6
Move from one covered and concealed position to another	
Lift weight from the ground (eg stretcher)	
Drag a casualty to safety	
Lift weight overhead	
Conduct a fireman's carry	
Push a HMMWV	
Fill a sandbag	
Pull up and through a window	
Carry a sandbag	
Throw a punch	
Throw a grenade	
Heave an object onto a platform	
Continuous movement under combat load (road march)	
Jump across a span and land	
Jump up	
Climb a ladder	
Climb a rope	
Climb over a wall	
Low crawl	
Traverse a horizontal object by hand	
Vault a low obstacle	
Other	

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